OPHTHALMIC SURGERY

AND MEDICINE

MANUAL
OF
OPHTHALMIC SURGERY AND MEDICINE

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PREFACE

In writing this Manual, my endeavour has been to make it systematic, practical, concise, and at the same time comprehensive.

The vast strides that ophthalmology has made during the last few years render it impossible, in a book of this size, to more than cursorily touch upon most of its branches; and the student desiring fuller information is referred to the various Treatises, many of which are alluded to in the text, and especially to the Transactions of the Ophthalmological Society of the United Kingdom.

My best thanks are due to my pupils, Mr. J. J. Grace, Dr. F. E. Colby, and particularly to Mr. E. Brewerton, for their able assistance.

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OPHTHALMIC SURGERY AND MEDICINE

CHAPTER I

EXAMINATION OF THE EYE

In the first three chapters I have thought it advisable to state, as clearly and concisely as possible, the different methods by which a student should examine thoroughly a case of ocular affection or disease. Each case cannot be examined completely as to every part of the eye, as time would not allow; but in most cases, by taking the patient's history as to the attack, and by observation, the parts to be specially examined will be soon recognised; the pages containing the description of these parts should then be referred to.

It is important, in the first place, to take short notes of the history of the ocular symptoms complained of by the patient, as to their onset, duration, and especially the existence of any previous eye trouble. If it is a case of error of refraction or accommodation, the question of whether the patient had ever worn spectacles, or for how long, should be gone into, and the strength of the spectacles should be measured and noted down. In many cases it is important to take some particulars of the general constitutional history of the patient, and of the family history (especially with reference to the immediate relations).

It cannot be too strongly impressed on the observer that the vision, at all events for distance, must always be taken for each eye separately.

The examination of the eye has been divided into two parts, viz.: The *objective*, by the unaided eye of the observer with or without focal illumination, and by the ophthalmoscope; and the *subjective*, for acuteness of vision, fields of vision, colour sense, and light sense.

Objective examination by the unaided eye without focal illumination.—Most of the following observations may be made without concentrating the light by means of a lens (*focal illumination*), provided that a good light is obtainable. This is best done by placing the patient facing a window.

In the first place, the general appearance of the patient must be carefully observed, and signs of constitutional disease, as syphilis, tubercle, gout, &c. looked for. The expression of the patient is often an important aid in diagnosis—for example, the vacant expression of the blind, the extreme lid spasm in children suffering from corneal ulcer, the heavy look of the lids in granular conjunctivitis, the prominence of the myopic eye, the inclination of the head to one side as in paralysis of an external ocular muscle.

In all the following observations it is very necessary that the two sides should be compared, and that every observation made on one eye should be repeated on the other if practicable.

The lids should be examined as to their skin surface and their movements; the condition of the ciliary borders should be carefully inspected by lifting the upper lid with the thumb of one hand, whilst the lower lid is pulled down by the index finger of the other hand. By this means the situation and direction of the eyelashes can be determined, and the position and size of the puncta.

To *evert the upper lid*, the patient must be directed, with his head erect, to look towards his feet, and thus relax the tissues of the upper lid. A probe or thin pencil, held in one hand of the observer, is laid horizontally along the skin of the upper lid, half-way between the ciliary margin of the lid and the superciliary ridge of the orbit. The eyelashes are taken between the forefinger and thumb of the other hand, and the lid pulled downwards and stretched. The probe is now pressed backwards and drawn from the nasal to the temporal side, when the lid is easily turned over it and everted.

To look at the eyes of children with spasm of the lids the following is the most convenient way. Two chairs of the same height are placed opposite one another; the observer sits in one, a nurse in the other, holding the child horizontally in her lap with the face upwards. The observer grasps the head of the child with his knees, whilst the nurse holds the arms and legs. He then places the index finger of his right hand on the upper lid and presses downwards towards the ciliary border, as if trying to hook the finger round this border, and thus draws the lid upwards, taking great care not to evert its edge. With the index finger of the left hand pressing on the ciliary border, he draws down the lower lid.

Extrinsic ocular muscles.—To test the power of these muscles the observer, holding an object, such as a pen, in his hand, should direct the patient to follow it carefully with his eyes, and to execute the complete lateral (abducting and adducting) and vertical (elevating and depressing) movements; at the same time, any halting action or involuntary oscillations (*nystagmus*) should be watched for. The associated action of the upper lid with elevation or depression of the eyeball must be noticed.

If a squint be present, the patient should be directed to follow the observer's finger moved in the opposite

direction to the squint, and if the squinting eye moves normally in this direction, the squint is concomitant, but if the eyeball halts, the squint is probably paralytic.

The amount of binocular convergence power may be roughly estimated by instructing the patient to fix the observer's finger, which is approached closely to the patient's face, the distance being measured at which convergence power is no longer possible, as shown by one eye turning out.

The lachrymal system, consisting of the lachrymal gland and passages, should be carefully examined if there be signs of lachrymation or watery eye. The *lachrymal gland*, situated at the superior external angle of the orbit, can only be felt from the exterior if enlarged. On everting the upper lid the *accessory lachrymal gland* may be seen as a slight swelling covered by a fold of conjunctiva. The border of the inner angle of the lids should be examined for the *puncta*, which in health are applied to the ocular conjunctiva, and only seen if the lids are slightly everted.

The *caruncle* situated at the inner angle is normally of a pinkish colour; if sunk or deeply placed, this probably denotes that tenotomy of the internal rectus has been performed. Extending from the caruncle is a pinkish fold, the *plica semilunaris*, the remains of the nictitating membrane.

A swelling above the internal palpebral ligament may denote a mucocele from lachrymal obstruction, and in this case pressure over the swelling will cause the contents to flow through the puncta.

The shape of the eyeball can be examined from the side and the front by raising the upper and depressing the lower lid. By this means elongation of the axis of the eye in myopia, shortening of the axis in hypermetropia, and the ovoid shape in astigmatism may be observed.

If prominence (*proptosis*) or recession (*enophthalmos*) of one eye be suspected, the patient should be seated in a chair, whilst the observer, standing behind and looking over the patient's head, raises both upper lids and notes the relative position of the anterior portion of the corneæ.

To examine the orbit the observer should stand behind the patient, and with his fingers feel the margins and press through the lids deeply into the recess (*oculo orbital sulcus*) between the globe and the walls of the orbit.

Tension.—The eyeball, consisting of fluid contents enclosed in a strong fibrous covering, gives a feeling of

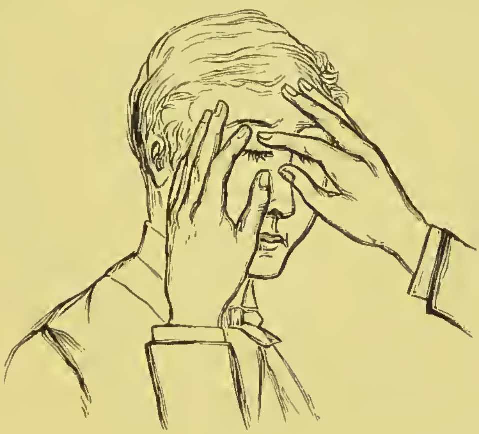


FIG. 1.—ESTIMATION OF TENSION

resistance to the fingers placed upon it, and this resistance is known as the intra-ocular tension, and varies in health and disease. *To estimate tension* (fig. 1).—The patient is directed to look at his feet, and close his eyelids, whilst the observer, standing opposite, places the tips of both index fingers on the outer surface of the eyelid just below the orbital ridge, and presses downwards on the globe, alternately with one finger and then with the other, as if trying for fluctuation. Bowman instituted a scale for comparison of tension, and described

the firm tense semifluctuating feeling of the normal eye as the mean (normal tension) represented by T.n. Any slight increase of this tension he called T+1, if the tension were greater still T+2, and if of stony hardness T+3. In the same way, he established a scale for diminished tensions, T−1, T−2, T−3. This, of course, is not an accurate method, and depends a great deal on the touch and practice of the observer. In the endeavour to render the estimation more scientifically exact, several instruments called *tonometers* have been invented, of which Priestley Smith's is the most reliable.

The conjunctiva is divided into the *palpebral*, lining the eyelid; and the *ocular*, covering the eyeball. To examine the palpebral conjunctiva of the upper lid it is necessary to evert the lid. Foreign bodies are often present on this part of the conjunctiva, and granulations are to be found, especially on the fold known as the retro-tarsal formed by the edge of the tarsal cartilage. The *fornix* or *cul-de-sac* produced by the palpebral conjunctiva passing to the ocular sometimes contains a foreign body.

The upper portion of the ocular conjunctiva is displayed by directing the patient with head erect to look down whilst the observer raises the upper lid; the lower part is seen by the patient turning his eye upwards whilst the lower lid is pulled down.

The *ocular conjunctiva* should be smooth and transparent, the white of the sclerotic with a few vessels being seen through it. In patients over forty there is generally, near the outer and inner edges of the cornea, on a level with the centre of the pupil, a small yellowish triangular patch (*pinguecula*).

The vessels (fig. 2) seen with the naked eye in inflammation may be divided into the following:—

1. The *posterior conjunctival* P.C., derived from the

palpebral and lachrymal vessels, are scarcely seen in health. In inflammation of the conjunctiva the vessels form a close network—scarlet or brick-red in colour—freely movable with the conjunctiva, not so distinct near the corneal margin, and not disappearing on pressure

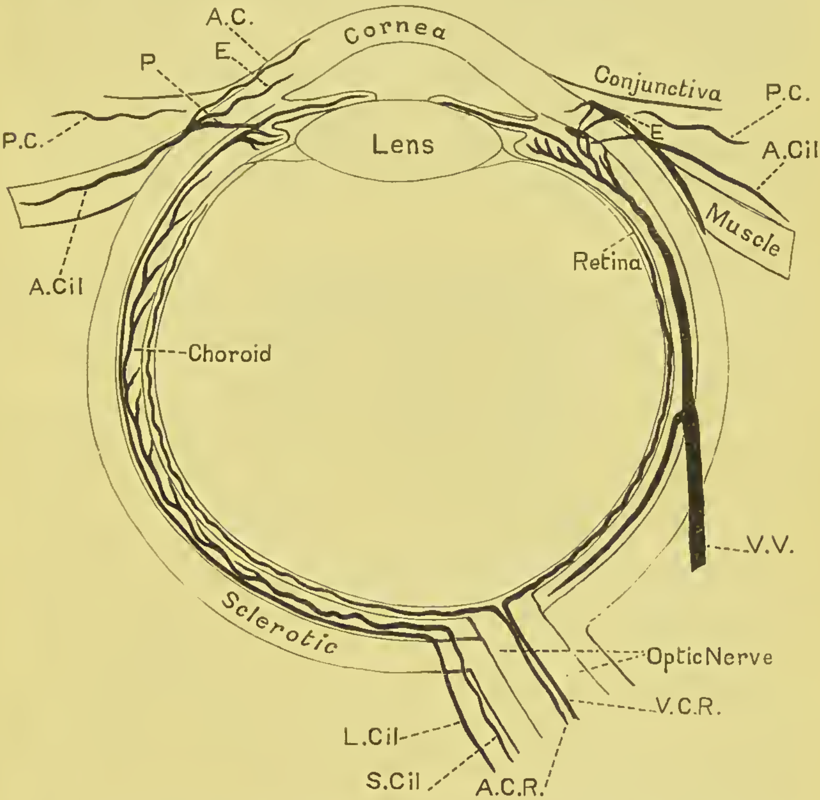


FIG. 2.—VESSELS OF THE EYEBALL. THE ARTERIES ARE REPRESENTED ON THE LEFT AND THE VEINS ON THE RIGHT

A Cil, L Cil, S Cil, anterior, long, and short ciliary ; A C, P C, anterior and posterior conjunctivæ. E, episcleral ; P, perforating ; V V, vena vorticosa ; A C R, V C R, central retinal artery and vein.

with the finger. In the network so formed, the veins and arteries are indistinguishable from one another.

2. The *subconjunctival* are branches or radicles of the anterior ciliary vessels A. Cil., and are divided into the perforating and episcleral.

(1) The *perforating* arteries, P, disappear about $\frac{1}{10}$ in. from the corneal margin, are very tortuous, and may be seen in health. They are especially well marked in glaucoma.

(2) The *episcleral* arteries, E, are not seen in health, but in disease form a pink zone of straight parallel vessels, surrounding and radiating from the cornea (*circumcorneal zone*). They do not move with the conjunctiva, and disappear on pressure. They are well marked in iritis and in keratitis. The *episcleral veins*, E, are dusky looking, and are found in glaucoma, cyclitis, and scleritis.

3. The *anterior conjunctival* vessels, A.C., which are superficial branches of the anterior ciliary, are bright red in colour, found near the corneal margin, and indicate superficial corneal mischief.

Œdema (*chemosis*) of the conjunctiva, generally associated with inflammation, is often seen. Enlargement of the lymphatic spaces, resembling strings of transparent beads or small cysts, is at times met with.

The sclerotic is seen through the transparent conjunctiva, and is generally described as being of a pearly-white colour, but occasionally it may be pigmented.

Objective examination by focal illumination (fig. 3).—The patient is seated in a chair facing the observer, daylight or artificial light being used. The observer holds a biconvex lens of about 13 dioptres (3 in.) between the patient's eye and the source of light, in such a manner that the light is concentrated or brought to a focus on the part to be examined. In order to do this more thoroughly, the observer can magnify the structure he is looking at by means of a second lens held in the other hand.

The Cornea must be examined as to its transparency, surface and sensibility. The reflection of external objects, such as the window-frame, should be sharp and bright;

any deviation from this would indicate the presence of facets or nebulæ.

To demonstrate the extent and presence of corneal ulcers a drop of fluorescin solution (F. 48) may be put into the eye, and after two or three minutes, on washing away the superfluous reagent by boracic acid, the ulcerated surface will be stained a bright yellow-green. The sensibility of the cornea may be tested by a small piece of thread or twisted cotton-wool.

The anterior chamber must be examined from the side and front as to its depth, by noting the distance

FIG. 3.—FOCAL ILLUMINATION

between the corneal reflection and the iris. The contents should be clear and transparent; if pus or blood be present, they gravitate to the most dependent part of the chamber.

The iris must be examined as to its colour, polish, and pupillary aperture. The colour of the iris when inflamed is altered, and as a rule this may be seen by comparing the two sides; in such a case a blue iris will become green. Marked differences in pigmentation of the irides are very common, and when of congenital

origin, the normal polish of the iris is not altered. During movements of the eyeball, the iris as a whole should not be seen to move; if the iris does oscillate (*tremulous iris*), dislocation of the lens or fluid condition of the vitreous is generally present.

The size of the pupil can be measured by a *pupillometer*; the author's (fig. 4) is used by holding the gauge close to the outer canthus, and by moving it up and down until one of the semicircles corresponds to the size of the pupil. For such observation the patient should be seated opposite a window in a good light, and told to look into the far distance. If there be any doubt about the reaction of the pupil, the observation can be made in a dark room with the ophthalmoscope.

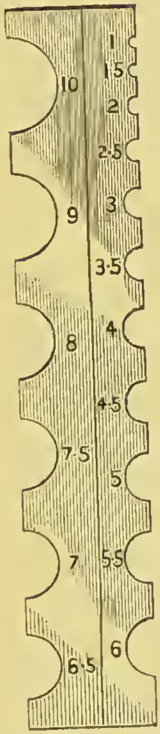


Fig. 4
Pupillometer

The pupillary aperture must be examined as to its size, shape, and position. The normal pupil looks black by reflected light, and is about 4 mm. in diameter, circular, regular, and slightly to the nasal side of the centre of the cornea. It should be equal to its fellow, and vary with it under different degrees of illumination. Thus, if one eye be shaded, both pupils should dilate equally; and if light be thrown into one eye, both pupils will contract to the same amount. The chief movements of the pupil are contraction and dilatation, and these alterations may be called contraction and dilatation reflexes. The *contraction reflexes* of the pupil are three in number: (1) *Direct light reflex*; this is obtained by throwing light into one eye, and observing the contraction of the pupil of this eye; (2) *Consensual light reflex*; which may be demonstrated by throwing an

increased light into one eye, and observing the contraction of the pupil of the other eye; (3) *Accommodation reflex*; obtained by directing the patient to fix a point about four inches from the nose in the middle line, when the pupil will contract. This contraction also takes place on the convergent movements of the eye associated with accommodation, and can be obtained, as a rule in the blind, by instructing the patient to try to fix his own finger at about four inches distance.

The *dilatation reflexes* are four in number. (1) *Direct shade reflex*; when one eye is shaded the pupil of that eye dilates. (2) *Consensual shade reflex*; when one eye is shaded the pupil of the other eye dilates. (3) *Accommodation relaxation reflex*; on relaxation of accommodation the pupils dilate. (4) The *sensory reflex*; on stimulating sensory nerves, as by tickling the hand, both pupils dilate.

The pupil dilates to mydriatics, as atropine, homatropine, and cocaine, and contracts to miotics, as eserine, or pilocarpine. Inequality of the pupils is of frequent occurrence in adult life, and in many cases has no pathological importance. The pupil is influenced by its blood-supply; in congestion of the iris the pupil contracts (*congestion miosis*). Slight rhythmic movements synchronous with respiration may often be observed.

The ciliary region.—In inflammation of this region palpation with the finger behind the periphery of the cornea occasions pain and tenderness.

The lens may be examined by the unaided eye, as far as the anterior capsule and the anterior part of the lens are concerned, but for thorough investigation the pupil must be dilated by homatropine and cocaine (F, 5*a*), and the examination made in a dark room by focal illumination and by the direct ophthalmoscopic method. With focal illumination and a dilated pupil, two images of the light ought to be seen—one upright, brighter, and

larger on the anterior surface of the lens, and the other inverted, not so well defined, and not so bright on the posterior aspect. These two images are a test for the presence of the lens, and are not present in *aphakia* (absence of the lens). A senile lens generally looks grey to the unaided eye when the pupil is contracted, and may be mistaken for cataract; but, with a dilated pupil, the direct close ophthalmoscopic examination (with a +10 D. to +15 D. lens in the sight-hole of the mirror) will immediately detect a true opacity in the lens, such opacity appearing dark grey against the red reflex of the fundus. Lenticular opacities may also be observed by the direct distant ophthalmoscopic method.

CHAPTER II

EXAMINATION BY THE OPHTHALMOSCOPE

The ophthalmoscope in its simplest form consists of a circular, silvered-glass, concave mirror, of about 20 cm. focal length, pierced by a central aperture called the *sight-hole*, 3 mm. in diameter. The mirror should be fitted into a metal disc supported on a handle. Such an instrument can be employed for direct distant ophthalmoscopic work, or for the indirect method; but, though possible, it is difficult to use it to advantage for the direct close ophthalmoscopic examination.

To remedy this, an arrangement like the nosepiece of a microscope is now generally used (fig. 5, D), bearing a large concave mirror of 20 cm. focal length at one end, and a small tilted mirror of 8 cm. focus at the other.

An ophthalmoscope (fig. 6) with a rectangular mirror (20 cm. focal length), capable of being brought forward and tilted to either side, admits of use for all methods.

In every ophthalmoscope there should be a series of lenses arranged to pass behind the sight-hole; the number of these lenses varies according as the instrument is intended for general medical use or for refraction purposes. For general use, the series of eleven lenses numbered in dioptres $(+1+2+3+4+9+20-1-2-3-4-6)$ as in the author's ophthalmoscope (fig. 6) is sufficient.

The best instruments are arranged on the plan of

the magazine ophthalmoscopes invented by Mr. Couper, and of these the most useful and popular is that of Mr. Stanford Morton (fig. 5).

This ophthalmoscope consists of twenty-nine separate concave and convex lenses, enclosed in an endless groove, and propelled by a driving-wheel (A). The driving-wheel (A) also rotates a disc (B), on which is indicated the strength of the lens presenting at the sight-

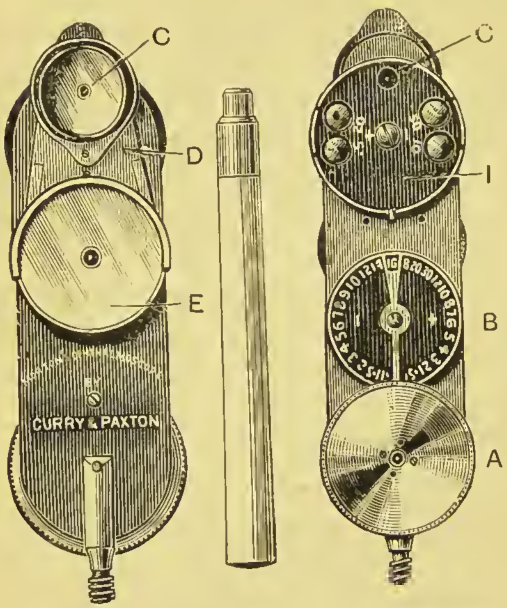


FIG. 5.—MORTON'S OPHTHALMOSCOPE

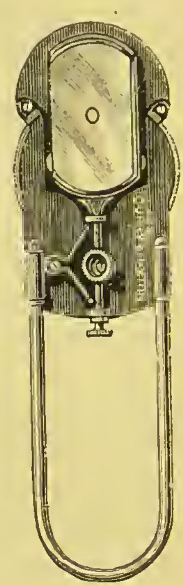


FIG. 6.—AUTHOR'S OPHTHALMOSCOPE

hole (C). On the front of the instrument is an arrangement (D) like the nosepiece of a microscope, carrying at either end a concave mirror; the larger (E), of 25 cm. focus, is for the direct distant examination (including retinoscopy) and the indirect method; the smaller (H), of 8 cm. focus, fixed at an angle of 25 degrees, admits of rotation round its central axis, and is for the direct close examination. There is also a separate disc (I) containing four extra lenses, which can be moved over

the sight-hole, so as to be used in combination with the others. If the observer have an error of refraction, it is useful to place a lens correcting such error in one of the holes of the disc (I).

A separate large biconvex lens of 13 dioptres (3-inch focal length), called the *objective lens*, should be included in every ophthalmoscope case.

General directions for examination by the ophthalmoscope.—In all the following descriptions it is assumed, unless otherwise indicated, that the observer is looking with his right eye at the right eye of the patient, and holding the ophthalmoscope in his right hand. If the left eye is to be examined, the same description will apply by merely substituting *left* for *right* in the text. It is usual to examine with the ophthalmoscope in a darkened room. The patient should be seated upright in a chair, and should be cautioned to keep the head at rest, and to move only the eyes when directed, and not the head. A small table should be placed beside the patient to support a lamp, but it is better to have a bracket lamp (gas or electric), which can be moved to either side of, or above, the patient. A candle may be used, but the small size and unsteadiness of the flame are great drawbacks. The observer sits in front, and preferably a little higher than the patient, and for this reason a music-stool, which can be raised or depressed, is most convenient. It is impossible for a beginner to follow practically the instructions given below, unless the patient's pupil is dilated by a mydriatic ; if not under atropine, the quickest and best [1]

[1] The best form of application is by means of separate discs of homatropine (gr. $\frac{1}{2500}$) and cocaine (gr. $\frac{1}{200}$). A disc of homatropine should first be put into each eye, and then one of cocaine, as the cocaine smarts considerably. A two per cent. solution of each—either watery or oily—of these drugs may be used, but the latter is objectionable from its rendering the cornea blurred, and the former is washed away by the tears.

way is to use homatropine and cocaine applied twice at intervals of ten minutes.

It is most important that the tension of every eye should be estimated before the pupil is dilated by a mydriatic.

There are two chief methods of ophthalmoscopic examination. 1. The *direct*, by means of the ophthalmo scope alone. 2. The *indirect*, by the ophthalmoscope

Fig. 7.—The Direct Distant Examination with the Ophthalmoscope

supplemented by the objective lens held in the other hand.

1. **The direct method** may be employed in two ways: The *distant* with a large concave mirror of 10-inch focus, and the *close* with, preferably, a small tilted mirror of short focus.

The direct distant ophthalmoscopic examination.—The light should be above and a little behind the patient's head, so that the face is thrown into shadow.

(Any low hat with a brim should be kept on the head.) The observer must be seated about 18 inches (45 cm.) in front of the patient, who should be told to look past the head of the observer to the end of the room. Holding the handle in his right hand, he raises the ophthalmoscope to his right eye in such a way that the mirror of the ophthalmoscope is vertical, with its reflecting surface towards the lamp, and its upper edge resting against the superior border of his orbit. He then looks through the sight-hole in the direction of the patient's face, and throws the reflected light from the mirror of the ophthalmoscope first on one eye and then on the other, when the pupillary apertures ought to be seen yellowish-red in colour (*red reflex*).

The observer now tells the patient to look in the direction of, and beyond, the observer's right ear or raised up right little finger, when the red reflex will appear lighter in colour, owing to the optic disc occupying the field of vision. Directing the patient to fix the sight-hole of the ophthalmoscope, the red reflex assumes a deeper colour, the yellow spot region having taken the place of the optic nerve.

Hints for beginners.—It is advisable for the observer to close his left eye when his right eye is being used, and *vice versa*.

To overcome the difficulty, at first experienced, of throwing the light from the ophthalmoscope mirror upon the patient's eye, it is useful for the observer to place the hand not holding the ophthalmoscope in front of the patient's eye, and to throw the reflected light on this hand. Now, removing the hand, the light will fall upon the eye. Most people use the right eye for choice, but it is very necessary that each eye should be used in turn. The proper way is that the right eye should be employed for the examination of the patient's right, and the left eye for the patient's left eye. The beginner having

succeeded in obtaining the red reflex, it is necessary for him to exercise a little patience, and to persevere in the following drill. He should, looking steadily through the sight-hole of the ophthalmoscope, keep in view the red reflex whilst executing the following movements. First, he should approach and withdraw his head from the patient several times; next he should move his own head from side to side; then he must rotate, slowly and by small movements, the mirror of the ophthalmoscope from side to side and from above downwards. Lastly, the observer's head being stationary, he should direct the patient to move his eye from side to side and from above downwards.

After having mastered the difficulty of illuminating the pupil, he should instruct the patient to look at the sight-hole of the ophthalmoscope, when the red reflex will become intensified owing to the yellow spot region occupying the field. The patient should now be told to look in the direction of the observer's right ear, so that the patient's right eye is directed a little inwards; the red reflex will appear lighter as the optic disc comes into view.

Having practised several times at obtaining the red reflex, it is advisable to try the so-called shadow test, or **retinoscopy**. For this purpose, the observer, sitting 3 feet from the patient, obtains the red reflex. He then moves the large concave ophthalmoscope mirror slowly in a horizontal direction from side to side, and as a rule should see a marked shadow moving from the pupillary border towards the centre of the pupil. This shadow either moves with or against the direction of rotation of the mirror. If the shadow takes the same direction as the movement of the mirror, the patient is myopic; but if it moves in the contrary direction, the patient is generally hypermetropic, though he may be myopic to the amount of 1 dioptre, or emmetropic.

The vertical axis of the eye can be investigated for the shadow test in the same manner, but the mirror of the ophthalmoscope must be rotated from above downwards, or below upwards. The vertical shadow is as a rule more difficult to obtain than the horizontal.

A fuller description of retinoscopy will be found in the chapter on Refraction.

The observer should now, by approaching and withdrawing his head from the patient, try if he can see the optic disc or retinal vessels.

When a vessel or the disc is seen, the observer, fixing it, should move his head from side to side, and if it moves in the same direction as his head, the patient is hypermetropic ; if, on the other hand, it moves in the opposite direction, the patient is myopic. If only the red reflex be seen, the patient is emmetropic or slightly myopic.

The *direct distant* ophthalmoscopic examination affords important information as to the condition of the media of the eye.

Thus, any opacities of, or other changes in, the cornea, may be detected by producing irregular shadows and distortion of the corneal reflex. These are often puzzling cases to the student, and must be also investigated by focal illumination. Further, if black or grey streaks are seen in the pupillary area, and the cornea has been proved to be clear, such objects may be situated either in the lens or in the vitreous. The patient should be told to move slowly his eye upwards, downwards, inwards, and outwards ; if these opacities move in the same direction as the eyeball, they are situated in the lens ; on the other hand, if they float about and continue to move after the eye is at rest, they are in the vitreous. Occasionally a large floating body in the posterior part of the eyeball may be a detachment of the retina.

The direct close ophthalmoscopic examination.—The lamp must be moved to a level with, and a little behind the patient's right eye, about 3 inches away from the head.

The observer holds the ophthalmoscope in front of his right eye, using the small tilted mirror, its base being towards the patient's nose. He then approaches his head to the right of the patient, keeping his own head parallel to the patient's, so that his (observer's) right eye covers

Fig. 8.—Direct Close Examination with the Ophthalmoscope

the patient's right eye, and his nose nearly touches the patient's right cheek. It is very important that this movement should be carefully practised, as at first it is difficult to focus the light on the eye, and at the same time to keep sufficiently close to ensure good and extensive illumination of the fundus. It must be remembered that both the patient and the observer should relax their accommodation. The observer can only achieve this by practice; but the patient's accommodation should be relaxed by homatropine and cocaine, or atropine.

It is advisable for a beginner, even if emmetropic, to

place a low concave − 2 D. or − 3 D. glass in the sight-hole in order to relieve him of the necessity of relaxing his accommodation, and this glass may, by practice, be gradually weakened or dispensed with.

To examine the *fundus*, the observer should carefully search for a blood-vessel, and then, by tracing it, the optic disc will be found. It is essential to remember that in order to investigate the optic disc the patient should be told to direct his gaze in the direction of the observer's right ear. For the examination of the yellow spot the patient must be told to look into the sight-hole of the ophthalmoscope, and by directing him to look upwards, downwards, inwards, and outwards, the details of the equator and periphery may be seen. It must be borne in mind that the image of the object investigated moves in the same direction as the ophthalmoscope mirror. If the patient have an error of refraction, a lens corresponding to such defect should be placed behind the sight-hole of the mirror; and if the observer himself be ametropic, his own refraction is to be corrected or allowed for.

The *refraction* of a patient can be estimated by the observer fixing a retinal blood-vessel, and then noting the highest convex lens in hypermetropia and the lowest in myopia, by which he can accurately focus this vessel.

The *vitreous* chamber can be explored by means of a lens of + 10 D. placed in the sight-hole of the ophthalmoscope, but it is well in examining the deeper parts of the vitreous, to use lenses diminishing from + 10 D. to + 1 D.

The *lens* may be investigated anteriorly by a + 18 D. lens, and posteriorly by the same lens as that used for looking at the anterior part of the vitreous, namely + 10 D.

The *cornea* can be examined by a + 20 D. lens.

In a normal emmetropic eye, the observer by the *direct close* examination should be able to investigate the

fundus without a lens in the sight-hole, the vitreous and lens with +10 D., and the cornea and anterior chamber with +20 D.

Indirect method of examination by the ophthalmoscope.—The patient is seated in a chair, with a lamp (gas or electric) a little above and behind his head. The observer, seating himself at arm's length in front of the patient, with his right hand holding the ophthalmoscope in front of his own right eye, reflects the light from the lamp on the patient's right eye, until the red reflex is seen. He then takes the biconvex *objective* lens of

Fig. 9.—The Indirect Examination with the Ophthalmoscope

13 dioptres (3 inches) focal length, between the thumb and forefinger of his left hand, and holding it 3 inches from the eye, places the tips of his second, third, and fourth fingers on the brow and anterior temporal regions of the patient. The light reflected from the ophthalmoscope mirror is now directed through the objective lens, which is shifted about until the red reflex is well obtained. The observer now tries to focus a retinal vessel with the lens, and after obtaining a glimpse of a vessel, he directs the patient to fix his (the observer's) right little finger, when the optic disc will come into view; this should

be carefully investigated, as, from the contrast in colour to the rest of the fundus, it is the easiest to examine. The difficulty experienced in focussing the details of the fundus is due to the image being in the air, and about 3 inches on the observer's side of the lens. A beginner should select a vessel or part of the disc, and observe the same point over and over again, until he can bring out its details clear and sharp. The yellow spot region may be seen by directing the patient to look into the sight-hole of the ophthalmoscope, and the rest of the fundus, by telling the patient to move his eye, and not his head, upwards, downwards, inwards, and outwards.

It is to be understood that everything seen by the indirect examination is inverted; structures observed apparently above are really situated below, and those seen to the nasal side belong to the temporal and *vice versâ*.

Further, the image of the object looked at moves in the same direction as the objective lens, and in the opposite direction to the observer's head.

If the observer wishes to see an object in the fundus to the left of that which is in his field of vision, he must move the lens to the right or his own head to the left.

A great trouble to be overcome by the beginner is caused by the reflection of the mirror on the cornea and on the objective lens. These images are often mistaken at first for the optic disc, and may be avoided by slightly tilting the lens.

Details of the fundus seen by the ophthalmoscope.—The fundus should be examined first by the *indirect* method, as by it a more comprehensive view is obtained, owing to the object only being magnified about five times; the indirect has also the advantage that the observer is farther from the patient, and that correcting glasses are not necessary. The examination afterwards by

the *direct* close method is generally advisable, as it gives a greater magnification (about 15 times) and enables minute changes to be investigated more completely. It is usual in describing the fundus to map it out into certain areas. Firstly, the optic disc and parts immediately around it; secondly, the yellow spot area; thirdly, the periphery, or the most remote part from the disc that can be investigated; and fourthly, the equator, or portion between the immediate surroundings of the disc and periphery.

The optic disc (Plate I. *a*).—The optic disc must be examined for its colour, shape, surface, centre, periphery and vessels. The normal *colour* of the disc is pinkish-grey, due to a combination of causes; it is a mixture of red from the nutrient vessels, dense dead white from the connective tissue, and yellowish-grey from the nerve fibres. The colour may vary from pink to violet in congestion, and from pink to white in anæmia and atrophy, but in all cases depends to a great extent on the contrast produced by the colour of the retina. The *shape* is nearly circular, but may be oval, with the greater diameter as a rule vertical. The nasal portion of the *surface* of the disc is pinker than the temporal, owing to the presence of a greater number of capillaries, and also to the fact that the nerve fibres are not so numerous in the temporal half. The nasal half can usually be separated from the temporal as the retinal blood-vessels on emerging from the nerve incline towards the nasal side. Near the *centre*, at the spot where the vessels divide, is a light depressed part of the disc known by the name of the *physiological cup*. At the bottom of the physiological cup may be seen a grey network, the *lamina cribrosa*. The physiological cup (fig. 10, A) is funnel-shaped, the broad part of the funnel being towards the surface of the disc. It differs greatly in size and position, and though generally most marked

Pl. I.

a

Normal Disc.

b

Albuminuric Retinitis.

near the middle, from contrast of colour, it may extend to the temporal border of the scleral ring. The nasal side of the disc, not being implicated in physiological cupping, is the part that should especially be investigated for a correct estimation of the true colour of the disc. It is often very difficult to distinguish between the physiological cup and slight pathological cupping of the nerve in glaucoma. In *glaucomatous cupping* (fig. 10, C) the nasal side is encroached upon, and at times quite obliterated, and there is an undermining at the circumference of the disc, so that the vessels are seen curling round the scleral ring. The extent of the glaucomatous cup may be the whole disc, and is generally more than half,

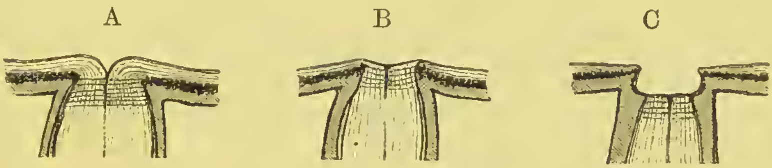


Fig. 10.—Cuppings of the Disc
A, physiological; B, atrophic; C, glaucomatous

whereas the physiological cup is as a rule under one quarter of the breadth of the disc. The *cupping of optic atrophy* (fig. 10, B) extends over the whole surface of the disc, and is shallow, the centre being a little more depressed than the edges. The vessels bend slightly, the arteries are reduced in calibre, and the colour of the disc is white or bluish-white like skim milk (Plate III. *b*).

In any excavation, such as the glaucomatous or physiological cup, the so-called *parallax* may easily be obtained by the indirect method. This is seen by moving the lens from side to side or from above downwards, when the whole fundus moves in the same direction as the lens; at the same time the floor or deeper part of the cup moving more slowly, the edge and superficial parts appear to move over the deeper parts.

Swelling of the disc (Plate III. *a*) is accompanied by indistinctness of its outline, and can be diagnosed from the difference in height[1] of the disc above the retina.

The *periphery* or margin of the disc is usually lighter in colour, and is known as the scleral or *connective tissue* ring. It is generally a mere ring, but in some cases, owing to the choroidal aperture being large, the nerve may be seen surrounded by a white zone, which must be carefully distinguished from a myopic crescent (Plate IV. *b*). Black pigment, arranged regularly in a crescent or circle, is often found on the outer side of the scleral ring, and is the pigmented edge of the choroidal aperture. The scleral border of the disc should be seen distinctly in health; but it is blurred and rendered indistinct in papillitis, retinitis, or choroiditis. In glaucoma (Plate IV. *a*) the edge of the disc is frequently surrounded by a well-defined scleral ring, resulting from atrophy of the choroid, the effect of pressure.

The blood-vessels (fig. 11).—The retinal artery emerges from the centre of the disc accompanied by its vein, which lies generally to the inner or nasal side. At its exit it divides into two trunks, known as the superior and inferior retinal arteries; each of these arteries bifurcates, as a rule on the disc, one branch passing to the nasal, and the other to the temporal side, making in all four chief branches—a superior nasal and superior temporal, an inferior nasal and an inferior temporal.

[1] The height of an elevated spot in the fundus such as a swollen disc, can be measured by the direct close ophthalmoscopic examination in the following manner. The number of the strongest convex lens with which the top of the elevation can be plainly seen is noted, and the difference between this lens and the one required to see the rest of the fundus distinctly is taken in dioptres, which can be rendered into millimetres by allowing three dioptres to the mm. In a similar way, a depression may be estimated by concave lenses, with this difference that the depth must be measured by taking the number of the weakest lens with which its details can be seen.

These four branches subdivide again into others, which, becoming smaller, end in capillaries, from which the blood is collected in veins corresponding to the arteries above enumerated. On the temporal side of the disc are two small arteries, branches of the retinal artery, accompanied by veins, which are distributed to the region of the yellow spot, the one above being called the superior macular, the one below the inferior macular artery. On the nasal side there are also two vessels—the superior and inferior median.

FIG. 11.—RETINAL VESSELS (DIRECT CLOSE OPHTHALMOSCOPIC VIEW; LEFT EYE)

S A, I A, superior and inferior retinal arteries, S T A, I T A, superior and inferior temporal arteries; S N A, I N A, superior and inferior nasal arteries; S M A, I M A, superior and inferior macular arteries; S Med A, I Med A, superior and inferior median arteries. The veins corresponding to the arteries are designated in the same way.

The *retinal arteries* are distinguished by their bright red colour, central whitish streak, definite edge, and absence of pulsation. They also differ, as a rule, from the veins in being smaller, less tortuous, and in occupying an anterior position. The *retinal veins* are dark red or maroon, and are uniform in colour; pulsation is frequently seen in them, especially near the disc. Small branches

from the posterior ciliary arteries, especially one on the temporal side, are frequently found piercing the disc and supplying the retina.

The **retina** is not, as a rule, visible in health except at the yellow spot. In hypermetropes there is a white sheen about the vessels (shot-silk appearance) known as the retinal reflex. Some small white spots may often be seen. In brunettes the fundus is dark and reddish-brown, owing to increase of the retinal pigment; and in very fair individuals, in whom the retinal pigment is scanty, the network of choroidal vessels is plainly seen.

The *yellow spot* (Plate I. *a*) is situated one and a half disc's breadth to the temporal side of, and slightly below the disc. It is generally oval, without visible vessels, and more pigmented than the rest of the retina; in the centre, a small bright spot can generally be seen.

The choroid.—The choroid, by means of its close network of blood-vessels, gives the red colour to the fundus (*red reflex*). The fairer the individual the smaller the amount of pigment, and therefore the clearer the definition of the choroidal vessels. The vessels of the choroid differ from those of the retina in that they are lighter in colour and form a close network with irregular spaces, which become larger towards the periphery.

CHAPTER III

SUBJECTIVE EXAMINATION OF THE EYE

Acuteness of Vision.—The vision of each eye should, if possible, be taken, at all events for distance, as this is a most important point to note for future reference and comparison. The methods for estimating vision are various, according to the amount of sight of the patient. It is usual to try the sight at first by means of test types, but it must be borne in mind that in the examination with test types alone, the observer is to a great extent at the mercy of the patient's answers; and, therefore, in the case of children, illiterate people, and impostors, such examination should always be checked by retinoscopy.

Test types are employed for estimating vision: (1) for *distance*; (2) for *close reading*. At the end of this book will be found examples of both kinds of types, arranged according to Snellen's method—that is, each letter is estimated at the distance indicated, under an angle of 5 minutes.

Test types for distance ought to combine the following characteristics: the letters should be separate, large Roman, square, black on a white ground, easily distinguishable, and suitably arranged as to sequence. A set is supplied at the end of the book, and the following description should be read with their assistance. The letters are numbered according to the distance at which

they should be seen accurately. The largest type (E) should be read at 60 metres, the next line (B T), with the same degree of accuracy, at 36, and the other lines in like manner, according to the numbering, at 24, 18, 12, 9, and 6 metres.

The diagram (fig. 12) shows that lines, and also letters, subtending the same angle (in this case 5′) increase in size according to the distance at which they are measured from O, but always bear the same ratio to one another. Thus A seen at 6 metres would correspond to E at 60 metres or B at 24 metres; and the letter E

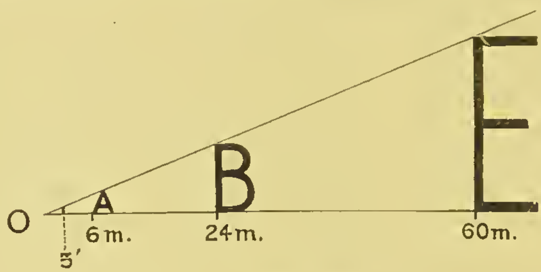


FIG. 12

would be ten times the size of A, and B four times the size of A.

It is customary, in using the distant test types, to express the patient's vision as a vulgar fraction, of which the numerator is the distance at which the type can be read, and the denominator the number corresponding to the type seen; thus if the line of the type marked 6 be read at 6 metres, the fraction denoting vision will be $\frac{6}{6}$, expressed as V. = $\frac{6}{6}$, which would indicate the same acuity as the largest type, 60, read at 60 metres, V. = $\frac{60}{60}$. Owing to the difficulty of obtaining a room of greater length than 6 metres, this is the greatest distance at which the types are, as a rule, tried.

Test types for close reading (near vision) are arranged so that each size should be read at the distance marked on it. In Snellen's type, the smallest, ·5, should

be read at 50 cm. (20 inches), the largest, 4, at 4 metres (13 feet), and the others at the distances indicated in the type.

The wire optometer (fig. 13) is an exceedingly useful instrument for estimating the near point, and is employed by measuring the shortest distance at which the wires are seen distinctly by each eye separately.

Fig. 13.—Wire Optometer

To test for distant vision.—The method of testing distant vision is to hang the distant types on a wall in a good light, and to place the patient at 6 metres distance from them. The middle line of the type should be on a level with the patient's eyes. The vision of one eye only is tried at a time, the other being kept carefully obscured by a fan or card held before it, and not by the patient's hand, as, if the eye be pressed upon, the vision is obscured for some short time afterwards. The patient is now instructed to read the type as far down as he is able; if he reads the last line, 6, at 6 metres, his vision formula is V. = $\frac{6}{6}$. If he cannot read the line marked 6, but can read the one above it, marked 9, V. = $\frac{6}{9}$, and in the same way $\frac{6}{12}$, $\frac{6}{18}$, $\frac{6}{24}$, $\frac{6}{36}$, $\frac{6}{60}$, bearing in mind that the denominator of the fraction representing the patient's vision is always the number of the line of smallest letters he can see.

In England, formerly, the distance at which the types were read was 20 feet and its multiples; thus V. = $\frac{6}{60}$ would have been denoted by $\frac{20}{200}$, and V. = $\frac{6}{12}$ by $\frac{20}{40}$. On the Continent the vision formula is represented by a decimal fraction, thus $\frac{6}{6}$ $(\frac{20}{20})=1$, $\frac{6}{12}$ $(\frac{20}{40})=\cdot5$, $\frac{6}{60}$ $(\frac{20}{200})=\cdot1$, and the rest in proportion.

If the patient cannot read the largest letter, 60, at 6 metres, he is told to approach the test types until he

can do so, and the vision is denoted $\frac{5}{60}$, $\frac{4}{60}$, $\frac{3}{60}$, $\frac{2}{60}$, $\frac{1}{60}$, according as he reads the line at 5, 4, 3, 2, or 1 metre.

Should it be impossible for him to read the largest letter, 60, at 1 metre, the *finger test* is tried. This is obtained by the observer standing in front of the patient and holding his fingers, preferably before a black ground as the coat, and measuring the greatest distance at which the fingers can be counted. This is noted as V.=' counts fingers at ·5 metre,' &c. Should the patient fail to count fingers, the hand or a large object is passed before the eye, and he is asked if he can see anything moving before him; if so, V. = 'perceives large objects.' The final test is obtained by throwing light into the patient's eye by means of the mirror of the ophthalmoscope in a dark room, and asking him if any light can be seen; if he sees light, V. = 'perception of light' (p.l.), but if he cannot see light, V. = 'no perception of light' (no p.l.).

To test for near vision.—The patient must be placed with his back to the light, in order that the test types given into his hand may be well illuminated. One eye being obscured by a fan or card, the patient is directed to read the smallest type he can at his own distance; this is noted, and also the nearest and farthest distances at which he can read it are measured in centimetres.

The type for close reading is most useful in cases of moderate and high myopia, as the farthest point at which the smallest type can be read is the measure of the degree of myopia. Thus ·5, seen as far off as 20 cm., would indicate 5 dioptres of myopia. These types are also used in estimating the accommodation.

Field of vision.—By this term is understood the extent or superficial area in which white or coloured objects are seen by one or both eyes.

To estimate the field of vision it is the custom to test each eye separately, and during the whole of the observation the eye under examination must be fixed

on some stationary object, which is known as the fixation spot, and corresponds to the central (yellow spot) area of vision.

The usual procedure in examining the field is, first to map out for white the extreme limit or periphery; within this limit, unless there be disease, the object used should be distinctly seen, except at one small spot, 'blind spot,' corresponding to the entrance of the optic nerve, and situated on the outer side of and a little below the fixation point. The word *scotoma* (σκοτος, darkness) is applied to any defect within the area of the field of vision where an object is not plainly seen. A scotoma is either relative or absolute. A *relative* scotoma is one in which there is not absolute blindness, but the acuteness of vision and colour perception are diminished. An *absolute* scotoma is one in which vision for objects and colours is quite lost.

The peripheral field for colours may be mapped out by coloured discs; as a rule the coloured fields are smaller than the white, and, as in the diagram (fig. 15), the fields diminish in the following order: white, blue, red, and green the smallest of all.

It must be remembered that the field is markedly greatest in extent towards the temporal side in either eye, the limited extent in the other directions being due to physical obstruction—that is, the nasal side by the nose, the superior border by the brow, and the inferior by the cheek. An important point to bear in mind in mapping out a field of vision is that the whole field is inverted with regard to the retina. Thus, in the field of vision the optic nerve area is situated at the temporal side of the fixation point, the nasal side of the field corresponds to the temporal side of the retina, the superior area of the field to the inferior part of the retina, and so on.

Another method of estimation is by placing the patient about 2 feet from a blackboard, and making a distinct

mark near the centre of this board to act as a fixation point. The patient steadily looking at the mark with one eye (the other being covered up), a piece of chalk, as an object, is moved from the outer limits of the board till the patient says he can see it, and a mark is made on the board at this spot with the chalk. This observation being repeated several times at different points, the peripheral limit of the field is mapped out.

Large defects in the field may be found out roughly by the observer moving his fingers in different directions

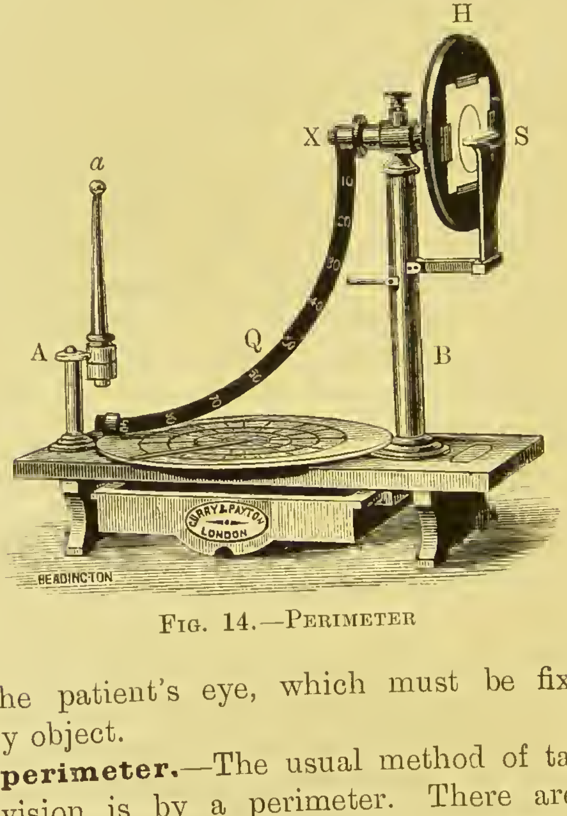


Fig. 14.—Perimeter

before the patient's eye, which must be fixed on a stationary object.

The perimeter.—The usual method of taking the field of vision is by a perimeter. There are several forms of the instrument, of which Priestley Smith's and McHardy's are the best. The illustration (fig. 14) represents the former, which consists of a stand supporting two uprights A and B. A bears a wooden pillar with a

knob (*a*) at the top. B carries a quadrant (Q) of metal with degrees engraved upon it; this quadrant is capable of being rotated by a wooden hand-wheel (H) attached to the axis. In front of the axis is a button (x) for the patient to direct his gaze at. At the back of the wooden hand-wheel is a slide for placing the chart, and also a horizontal scale (s) with divisions corresponding to the circles on the chart.

The patient sits down at a table with the instrument upon it, and approaches the perimeter so that the knob is

Fig. 15.—Perimetric Chart for White, Blue, Red, and Green

about $1\frac{1}{2}$ inches below the eye to be examined; the other eye is closed by a light bandage or patch. The patient now fixes the ivory button (x) in the centre of the axis of the instrument. The quadrant is at first placed horizontally, so that the drawing pin on the hand-wheel is above, and a perimeter chart is slipped into its frame. The observer stands facing the patient, and takes in his hand a rod, at the end of which a piece of white paper 10 mm. square is fixed. This paper is moved

along the inside of the quadrant (keeping the paper parallel to the quadrant), from the outer extremity inwards. The patient is instructed to raise his hand directly he sees the paper approach, and, the angle being read off the quadrant, the observer pricks the chart at the number on the scale (s) corresponding to the angle on the quadrant. The quadrant is then turned round 30°, and the observation recorded in the same way, and so on until the quadrant arm arrives at the starting point. The chart (fig. 15) represents a normal chart for white and other colours. If the patient's acuity of vision is so much reduced that he cannot distinguish a small piece of white paper, the field may be mapped out in the dark room by means of a small lighted taper in place of the white paper.

A rapid and easy method of finding any *defect in central vision* is by making the patient fix, with one eye, the observer's finger at about 18 inches distance, the other eye being closed. A piece of card, varying from 1 mm.–10 mm. square, fixed in a holder, is placed in front of the observer's finger, and the patient asked if he can see it; it is then moved slowly to the outer, upper, inner, and lower sides of the fixation point. Red is the best colour for this test, as it is the least-easily distinguishable colour, and is that which is first lost in toxic amblyopia, by far the most common cause of central defect of vision.

The perimeter is also useful in estimating the angle of squint and the degree of excursion and incursion of the eyeball, see Chapter XXI.

Colour Vision

To test for colour vision.—This is best done by means of coloured wools or the spectroscope. Wools are convenient, as they can be obtained in a great variety of tints, are easily handled, present a uniform colour when

looked at from every direction, and have not the sheen that printed colours possess. Professor Holmgren's method is generally followed. Two test skeins are selected, and the patient is required to pick out from a heap of various coloured wools any that match the test skeins. The first test is a very pale pure green; a colour-blind patient will match with it green, yellow, brown, and grey. The second test skein is a pink, and is the complementary of the green test; a colour-blind patient will select pink, pale blue, mauve, and violet.

Another method is by instructing the patient to pick out all the wools of a certain colour, such as green or red, to note the colours he selects, and to watch carefully for any hesitation in his choice. Daylight is the best illumination, but artificial light makes very little difference in obtaining the correct result. The examination by the spectroscope[1] is more difficult, and should only be used as supplementary to the wool test.

At the end of the book is a coloured plate copied from Professor Holmgren's work, and a description of it is given in the Appendix.

Light Sense

To test for light sense, or power of distinguishing degrees of illumination, different forms of photometers have been invented. Chibret's consists of a brass cylindrical tube, with an eye-piece at one end, and at the other, two equal circular discs, which can be illuminated by directing the instrument towards the source of light. By a mechanical contrivance one of the discs can be darkened gradually according to a scale marked on the instrument.

[1] For the best description of the subject, see Captain Abney's book on *Colour Vision*.

In examining a patient the two discs must at first be equally illuminated, then the degree on the scale is read off at which is perceived the difference by obscuring gradually one disc, and this is called the *light difference.*

Another way is to start with one disc darkened, and then take the degree on the scale at which this disc is first perceived to be lighter; this is called the *light minimum.*

CHAPTER IV

DISEASES OF THE CONJUNCTIVA

Anatomy.—The conjunctiva is a mucous membrane lining the inner aspect of the lids and the anterior portion of the scleral coat of the eyeball. These two portions are called respectively the palpebral and ocular conjunctiva, are in health freely movable over one another, and are kept moist by the secretion of the lachrymal gland. When the lids are shut the conjunctiva forms a closed sac, communicating by means of the puncta with the nasal passages, and owing to this communication operation wounds on the eyeball are with difficulty kept aseptic.

The *ocular conjunctiva* is continuous by its epithelial lining with that of the cornea: this accounts for the frequent simultaneous affection of the cornea and the conjunctiva.

In like manner the palpebral conjunctiva is continuous with the skin of the lids, and hence is often implicated in disease of the lids, especially of the ciliary border.

The ocular conjunctiva is transparent, the sclerotic being visible through it (*white of the eye*). A few blood-vessels, even in health, can usually be seen in the membrane, and move with it if pressure be applied. It is covered by stratified epithelium, contains no glands, and is freely movable over the sclerotic except near the periphery of the cornea, where it is firmly bound down and known as the *limb* of the conjunctiva.

The *palpebral conjunctiva* is continuous with the ocular conjunctiva at the fornix or cul-de-sac. It is lined by cylindrical epithelium and contains several mucous glands, especially in the fornix and retrotarsal fold (see below). The portion lining the tarsus (*tarsal conjunctiva*) is more firmly attached than the rest of the palpebral conjunctiva; it is smoother, contains fewer glands, and varies in colour from whitish yellow to pale pink. At the posterior border of the tarsal cartilage the conjunctiva is less firmly bound down and is thrown into horizontal folds (*retrotarsal folds*). The lymphoid tissue is more developed in this portion, which frequently presents, even in health, numerous small elevations or follicles. The *vascular supply* of the conjunctiva is from the posterior ciliary vessels, except near the cornea where branches of the anterior ciliary supply it. The *nerves* are derived from the fifth cranial nerve.

Hyperæmia of the conjunctiva is characterised by congestion of the posterior conjunctival vessels, and is often difficult to distinguish from conjunctival inflammations, resembling them in the subjective ocular symptoms of a feeling of grittiness and general discomfort, but differing in the absence of conjunctival discharge. It is occasioned by exposure to irritants, as dust, tobacco smoke (especially cigarettes), cold winds, salt water, and glare such as electric light and snow. The condition is also met with in cases of refraction error, insufficiency of convergence power, chronic alcoholism, gout, and in the early stages of zymotic diseases. In long-standing cases the dilatation of the vessels becomes permanent, giving rise to the *bloodshot* eye. The treatment consists in removal of the exciting cause.

CONJUNCTIVITIS.—The conjunctiva being a mucous membrane, is subject, like other mucous surfaces, such as the urethra, nose, and pharynx, to mucopurulent, purulent, membranous, and granular inflammations. By

development it is an epidermal structure, which accounts for the frequent occurrence of papules, usually called phlyctenules.

Inflammation of the conjunctiva, here called conjunctivitis, is often described as '*ophthalmia,*' which however is misleading, as the term is applied to other diseases of the eye such as sympathetic ophthalmia.

Conjunctivitis is generally accompanied by the following symptoms and signs: a feeling of grittiness, heat, and heaviness of the lids; the lids stick together during sleep, and there is injection of the posterior conjunctival vessels, accompanied by a discharge from the eye. It may be divided into the following varieties: mucopurulent, purulent, membranous, follicular, granular, and phlyctenular.

Mucopurulent (*catarrhal*) **conjunctivitis** is perhaps the most common of all eye diseases, and is characterised, as its name implies, by a discharge from the conjunctiva of mucus, generally mixed with pus cells. From the variety of its causes, this disease is found affecting persons of every age and nationality. It attacks both eyes as a rule, though there is usually an interval of a few hours or even days before the second eye is implicated. It occurs occasionally in epidemics, when it is contagious; it is prevalent at certain times of the year as in the spring, and varies greatly in severity.

Symptoms.—In a *slight* case, the patient complains of a smarting pain associated with a feeling of grittiness like sand in the eye, an uncomfortable feeling of stiffness of the lids which stick together during sleep, and lachrymation. Occasionally there are temporary obscurations of vision and halos round lights, due to secretion in front of the cornea; these, however, disappear for a time on rubbing the eye. The conjunctiva is in a state of slight general congestion; there is some discharge containing flakes of lymph to be found, as a rule, about

the inner canthus. In the *more severe* cases, which are generally epidemic in character, the usual symptoms, as heaviness of the lids, lachrymation, and grittiness, are exaggerated. The lids with their ciliary margins are swollen and congested. The palpebral conjunctiva is reddened and swollen, the ocular conjunctiva œdematous, the posterior conjunctival vessels much congested, and small reddish patches resulting from hæmorrhages are generally present. The colour of the congestion may be described as brick-red or scarlet. The discharge is at first serous containing mucus, and afterwards mucopurulent, and may be very profuse. In a few adult cases the symptoms are so acute that it is at first difficult to distinguish them from those of purulent conjunctivitis. In these *most severe* cases, the lids are so swollen that the patient cannot voluntarily open his eye, and on separating the eyelids a profuse thick mucopurulent discharge comes away. The ocular conjunctiva is thickened, vascular, and chemosed, with extravasation of blood in its substance, and the palpebral conjunctiva is congested and velvety in appearance, with flakes of lymph upon it. These flakes sometimes assume the form of a pellicle which strips off easily.

Course.—Ordinary acute cases ought to be cured in a week, but if left to themselves may last from two to three weeks and afterwards assume a chronic form.

Complications are rare, and include ciliary blepharitis and corneal ulcers; the latter are generally of the phlyctenular form and situated at the corneal margin.

In children, phlyctenules of the conjunctiva are often met with in mucopurulent conjunctivitis.

Prognosis.—It is very rare, even in the most severe forms, for any permanent damage to result.

Causation.—Being associated as a rule with a specific organism, the disease is generally acquired by contagion and is air-borne. It is therefore met with in people living

under the same bad hygienic and atmospheric surroundings, such as overcrowded dwelling-houses, industrial schools, and insanitary camps. In London a change of wind, especially in the spring, will crowd an out-patient department with cases of this disease, which as quickly disappears with alteration of the weather. Cases of old granular lids are peculiarly susceptible, and patients having once suffered from any form of mucopurulent conjunctivitis seem to be liable to a recurrence. Irritating fumes such as ammonia, the local application of atropine and eserine, or foreign bodies, may be exciting causes. Chronic cases are often aggravated by constitutional causes, such as gout and dyspepsia, and above all by errors of refraction and convergence power. The disease may be secondary to inflammation of the nose and lachrymal passages, affections of the eyelids as entropion and ectropion, and it also occurs in the course of the exanthemata, especially measles and influenza.

Treatment. Local.—In cases associated with a good deal of discharge, the eye should be kept free from this by bathing with weak antiseptic lotions, as boracic acid (F. 24), salicylic acid (F. 30), perchloride of mercury (F. 34), nitrate of silver (F. 35). An efficient and easy way to apply these lotions is by soaking a pledget of absorbent cotton-wool in the solution. The wet wool is held over the inner canthus (the patient preferably lying down and keeping the eye open) and allowed to drip in a continuous stream on the eye. This should be done three or four times a day. All discharge and dried secretion should be washed away, and a simple ointment applied to the margin of the lower lid inside the eyelashes with a camel's-hair brush, or with the clean finger, especially at night to prevent the lids sticking together during sleep and thus causing retention of secretion. In subacute and chronic cases it is advisable to use astringent drops, as sulphate

of zinc (F. 17), sulphate of copper (F. 22), or alum (F. 20). Before applying the drops, any discharge should be washed away by one of the above lotions, and care taken that the drops are applied between the open lids.

In some chronic cases local applications to the surface of the conjunctiva must be made by the surgeon, who should stand behind the patient (sitting in a chair) and evert the upper and lower lids so that the palpebral conjunctivæ of both lids form a continuous surface covering the eyeball. He then paints the conjunctival surface with a solution of silver nitrate (gr. x–℥j) or rubs it with mitigated nitrate of silver stick (F. 45) or a crystal of copper sulphate. After such application the surface must be washed with water, to which, in the case of silver nitrate, a little salt should be added, so as to form the chloride of silver. These applications should, as a rule, be used only once or twice a week. Lead lotion (F. 23) was at one time much employed, but has fallen into disrepute owing to the fact that lead forms a white deposit if the cornea is ulcerated. Alum is also dangerous if the cornea be affected, as it loosens the corneal cells and produces ulceration.

In chronic cases the refraction should be tested, as hypermetropia and astigmatism may produce, or at all events aggravate, the condition. Bandages and poultices must on no account be used. Care must be taken to remove all sources of irritation, as foreign bodies, strong light, or smoke; and further, the condition of the lachrymal passages should be examined. Dark glasses are useful at times.

General.—The general health must not be neglected, especially as regards digestive trouble and gout in chronic cases. The patient should not be confined to the house unless absolutely necessary, but ought to wear a shade over his eyes when out of doors.

Patients must be warned of the contagious nature of the disease, and avoid using the towels and washing appliances of other people.

Purulent conjunctivitis is an acute affection, characterised by the severity and rapidity of the onset, and, as its name implies, is accompanied by the discharge of pus. It is extremely contagious, and is microbic in origin, the specific organism in every case I have examined lately being the gonococcus. The disease may be conveniently divided for clinical purposes into two classes, adult and infantile.

Adult purulent conjunctivitis (*gonorrhœal ophthalmia*) is the more serious affection, and is due to actual contagion with the virus of gonorrhœa. The period of incubation may be from a few hours to three days.

In almost all cases the disease affects one eye only; this is due probably to the fact that the second eye is generally protected by a Buller's shield in time.

The *first* stage of the disease, lasting only a few hours, resembles that of a severe attack of muco-purulent conjunctivitis, and is characterised by stiffness of the lid, smarting pain, and lachrymation. These symptoms are quickly followed by redness, swelling, and œdema of the lids, especially the upper one, which is generally more swollen than, and often overlaps the lower. The ocular conjunctiva, at first scarlet and congested, becomes swollen and infiltrated with serum (chemosis); the discharge is serous and sometimes blood-stained.

The *second* or purulent stage is ushered in by a profuse purulent discharge; the lids become still more swollen, so that it is with difficulty they can be opened, and eversion of the upper lid is often impossible. On separating the lids, the conjunctiva is seen to be generally swollen, and the ocular portion protrudes as a red mass through the palpebral aperture.

Examination of the eyeball in such cases must be very

carefully carried out, as abrasion of the corneal epithelium, and even rupture of the cornea, has followed forcible and careless opening of the lids. If the palpebral conjunctiva can be seen it is also found to be much congested, reddened, and thrown into horizontal folds with pus lying in the sulci. The ocular conjunctiva becomes more swollen till it is raised above the corneal surface, and is of a greyish colour.

If untreated the purulent stage lasts about six weeks, and is followed by mucopurulent conjunctivitis and a granular condition of the lids; but if treated successfully it may subside in about a fortnight. When the swelling of the conjunctiva is very intense, ulceration of the cornea occurs as a rule near the periphery.

The preauricular lymphatic glands are usually swollen and tender.

The *complication* most often seen is corneal ulceration due to cutting off by the swollen conjunctiva of the nutritive supply of the cornea, or to spreading of the septic material in the corneal tissue. The ulcer is generally a marginal one, preceded by a dry, hazy condition of the cornea.

Such ulcers, owing to the lowered vitality of the cornea, tend to increase in depth, and often perforate, giving rise to prolapse of the iris. This is followed by septic iritis, and may result in panophthalmitis, with subsequent shrinking of the eyeball; corneal staphyloma with great impairment of vision may also occur. The earlier the corneal ulceration appears, the more serious are its results.

Treatment must always be energetically and carefully carried out, as in neglected cases the eye is destroyed in a few days. The patient must first be put to bed, and a Buller's shield fixed over the unaffected eye. This *shield* consists of a watch-glass laid between two layers of strapping, in each of which a central circular

opening is cut. The posterior layer, which is smaller than the anterior, adheres to the latter, and to the concave margin of the watch-glass, while that part of the anterior layer which extends beyond the margins of the posterior, adheres to the skin of the brow, temple, cheek, and side of the nose, the centre of the watch-glass lying over the eye. At the temporal side of the orbit an opening is left for ventilation. The indications for treatment are, in the first place, to allay the inflammation and get rid of the discharge. The inflammation is best combated by iced cold applications; a convenient method of applying these is by means of Leiter's tubes or ice pads. The eye must be washed free from discharge by absorbent cotton-wool soaked in any of the following lotions: boracic (F. 24), Condy (F. 33), weak nitrate of silver (F. 35), perchloride of mercury (F. 34), once every hour. It must be remembered that, as these cases always occur in individuals broken down in health, time should be allowed for sleep, and that the washings must therefore be less frequent at night. If possible, the inner surfaces of the lids should be painted with strong nitrate of silver solution (gr. x–℥j) once daily. Ulceration of the cornea may be treated by the actual cautery, and iodoform. If there be much swelling of the lids, the external canthi can be divided by scissors.

As this disease is due to inoculation, all patients suffering from gonorrhœa should be warned of the risks they run in conveying the contagion to the eye by the fingers or by towels.

Infantile purulent conjunctivitis (*ophthalmia neonatorum*) occurs in new-born children, and the symptoms show themselves, as a rule, on the third day after birth. It affects generally both eyes, and is due to inoculation from the vaginal discharges of the mother. It is microbic in origin, and the gonococcus is found in the discharge from the eye. The sequelæ of this disease

are so disastrous that owing to them[1] 30 per cent. of all blind people in the United Kingdom have lost their sight. The *symptoms* are similar, but not, as a rule, so severe as in the adult form. The lids are swollen, red or bluish-red in colour, and their ciliary margins are glued together by discharge. On opening the lids the palpebral fissure becomes filled with pus, obscuring all view of the eye; when this is wiped away, fresh pus wells up, and must be washed off until the cornea and conjunctival surfaces can be seen. The palpebral conjunctivæ are red, granular-looking, and tend to protrude and fill up the palpebral aperture unless care be taken to prevent this eversion of the lids. Occasionally in infantile purulent conjunctivitis a membranous pellicle, due to coagulation of the discharge, is formed on the palpebral conjunctiva. The ocular conjunctiva is less swollen and chemosed than in the adult form; the cornea is not so likely to become involved, nor the eye to be destroyed, if the disease be properly treated.

There are, however, some cases in which, owing to the general health of the infant, treatment has no effect in averting the disastrous results.

The chief *complications* are corneal ulcers, leukoma adherens, iritis, anterior polar cataract, and panophthalmitis followed by shrinking of the globe. Certain affections of the lids, as ectropion and entropion, may occur, and probably result often from the too free use of caustics. Later complications are anterior staphyloma, nystagmus, and squint.

[1] The Ophthalmological Society, recognising the great importance of early and efficient treatment in this disease, memorialised in vain the Local Government Board to issue to every one registering a birth the following instruction: 'If the child's eyes become red and swollen, or begin to run with matter within a few days after birth, it is to be taken, without a day's delay, to a doctor. The disease is very dangerous and, if not at once treated, may destroy the sight of both eyes.'—*Trans. Ophth. Soc.* vol. v. 37.

Treatment. Local.—In these cases Buller's shields, Leiter's tubes, and iced compresses cannot be used owing to the delicacy of the structures. The eyes must be washed every two hours with antiseptic lotions, as boracic acid (F. 24), alternating with Condy (F. 33) and nitrate of silver drops (F. 21). It is very necessary for the child's health that it should sleep well, and therefore the washing out should not be persisted in too often at night unless absolutely necessary.

The lids ought to be everted and painted once every other day with nitrate of silver solution (gr. x–℥j). But it must be borne in mind that the mucous membrane in such young children is very delicate, and too zealous cauterisation will result in cicatrisation and subsequent entropion or ectropion. In order to prevent the discharge accumulating, a little ointment, such as zinc, should be placed along the ciliary edge of the lids at night to prevent them from sticking together.

The lids can generally be opened by the fingers, and retractors should be used as seldom as possible, owing to the danger of abrading the cornea, and thus producing a focus for infection. This disease, in many cases, can be traced to the fact that the eyes have not been washed with an antiseptic solution at birth. Many instances are known in which, owing to the ignorance of midwives and a widely spread superstition, the eyes have been first washed with the mother's urine. In every case of childbirth, the eyes of the child should be bathed at once with an antiseptic lotion, and a solution of nitrate of silver (F. 35) is the most efficient. The few instances I have seen, after this preventive treatment has been carried out, have been abortive cases, generally appearing about the ninth day. The administration of vaginal douches before the onset of labour acts as a further precaution.

General.—It must be remembered that the general

health of the infant should be carefully attended to, especially with regard to hygienic measures.

Membranous conjunctivitis includes all those cases of inflammation of the conjunctiva associated with the presence of membranous exudation. They may be divided into two classes: *Diphtherial*, associated with general diphtherial infection and the presence of Lœffler's bacillus; *Non-diphtherial*, consisting of cases without evidence of diphtheria, chiefly due to the local action of caustics, scalds, burns, and drugs (jequirity).

Diphtherial membranous conjunctivitis may exist in varying degrees of severity; the severe form first described by Von Graefe is rarely seen in England.

In such cases the symptoms are great pain, swelling, stiffness, and brawniness of the lids, and at first some serous discharge from the eye, with swelling and chemosis (χήμη, gaping like an oyster) of the ocular conjunctiva. It is as a rule impossible to evert the lids, but if this can be done, greyish patches are found which tend to coalesce and involve the whole surface of the palpebral conjunctiva. The membrane involves the subconjunctival tissue, leading to necrosis of the parts implicated, and the slough so formed gradually separates and exposes a granular surface discharging pus. The *membranous* stage usually lasts from six to ten days, and is followed by acute mucopurulent conjunctivitis. The *sequelæ* of the disease are very serious, and generally lead to destruction of the eye from deep corneal ulceration with consequent perforation, or even panophthalmitis. The lids are also affected by cicatrisation. In less severe cases, the membrane does not implicate so deeply the subconjunctival tissue, and recovery may take place without any affection of the cornea having occurred, and without leaving any permanent damage to the lids.[1]

[1] See *Trans Ophth. Soc.* vol. xv. p. 55.

Non-diphtherial membranous conjunctivitis is chiefly due to injury of the conjunctiva by molten metal as lead, alkalis, acids, scalds, burns, fumes of gases as ammonia, and drugs as jequirity and silver nitrate. Occasionally a distinct membrane is found, especially on the upper lid, in a few cases of purulent or mucopurulent conjunctivitis. The membrane in these cases does not affect very deeply the subconjunctival tissue, and, as a rule, can be stripped off with comparative ease, leaving a raw bleeding surface. The great danger, in traumatic cases, is the tendency to the formation of adhesions between the palpebral conjunctiva and the ocular conjunctiva or cornea, known as *symblepharon*. The membrane, after being shed, may form again, and some cases have been recorded in which this condition has recurred at intervals for years.

Pathology.—In diphtherial cases Lœffler's bacillus is always to be found. In every case I have examined of conjunctivitis associated with membrane, bacilli have been found in considerable numbers, and these are very difficult to distinguish from Lœffler's, and have been described as the bacilli of xerosis.

Treatment. Local should consist of antiseptic lotions, as boracic acid (F. 24), corrosive sublimate (F. 34), nitrate of silver (F. 35), and quinine (F. 31). Opium drops are useful for stimulating the mucous membrane and relieving the pain. Cold compresses and hot fomentations may be employed. In diphtherial cases involving one eye, the other must be protected by a Buller's shield (p. 46). In the cicatrisation stage, oil (castor or olive) must be dropped into the eye, and any adhesion broken down daily to prevent permanent symblepharon. Owing to the extreme danger of the diphtherial poison, great care must be exercised in dressing such cases.

General.—In diphtherial cases antitoxin should be employed, and in many quinine is indicated.

Follicular conjunctivitis is a non-contagious disease, characterised by the presence of small greyish-white semi-transparent elevations (*follicles*) on the conjunctiva of the lower lid, chiefly near the retrotarsal fold; they may also be present on the conjunctiva of the upper lid.

The disease affects the young in all grades in life, being rarely met with after the age of 20; it is found in those living under the same hygienic conditions, as in boarding schools. The *symptoms* are weariness of the eyes, especially after much close work, a heavy feeling in the lids, lachrymation and photophobia. The follicles vary much in appearance and size, from small pink overgrowths to yellow semi-transparent bodies, and are discrete and arranged in rows parallel to the border of the lid. The posterior conjunctival vessels are sometimes congested.

The *duration* of the disease is very protracted, and may last for months or even years, and the *cause* is unknown. *Complications* are rarely met with, and vision as a rule is unaffected. By many it has been described as an early condition of granular conjunctivitis, but the two are quite distinct. Follicular conjunctivitis affects the lower lid, is not accompanied by much discharge, and followed by no cicatricial changes; whereas granular conjunctivitis affects chiefly the upper lid, is at times accompanied by a marked discharge, and gives rise to much cicatrisation.

The palpebral conjunctiva of many children may be found studded with slight pink elevations, and this condition is very difficult to distinguish from follicular conjunctivitis, and has been called *folliculosis*. Children with such conjunctivæ are susceptible to attacks of conjunctivitis, and are generally the subjects of adenoid vegetations, enlarged tonsils, and delicate throats.

Pathology.—In the normal conjunctiva of a young individual there is a considerable quantity of lymphatic

tissue, especially in the neighbourhood of the retrotarsal folds, and this tissue is still more abundant in children with a tubercular diathesis. The subepithelial lymphatic tissue becomes massed together in places into ovoid heaps of various sizes. These heaps or follicles have no capsule, and after lasting some time tend to disappear. They may either degenerate and become absorbed, or may, on absorption of the superimposed epithelium, discharge their contents.

Treatment.—Follicular conjunctivitis being chronic, and dependent on the general health, it is necessary that children should be placed under the best hygienic conditions, and care taken to test the refraction. Locally, the surface of the follicle may be painted with lotions of nitrate of silver (F. 35) or corrosive sublimate (F. 34). Occasionally sulphate of copper crystal may be used, and the contents of the elevations, if large, may be squeezed out between the finger and thumb. Any application likely to produce cauterisation must be avoided for fear of cicatrisation, as the after effects of such treatment may be more serious than those of the disease.

Cases resembling follicular conjunctivitis, characterised by slight roughness of the palpebral conjunctivæ and enlargement of the follicles, are met with where drugs, such as atropine, eserine, and cocaine, have been freely applied to the eyes. Use of the drug must be discontinued, and the conjunctivæ treated locally as above.

In adults, the subjects of gout, a roughened condition of the palpebral conjunctiva may often be found, associated with a smarting, pricking, burning pain in the eye. To this condition the term *hot eye* has been applied by Hutchinson. The treatment is principally constitutional by colchicum, &c., and locally by sedative lotions and ointments.

Granular conjunctivitis (*granular ophthalmia, trachoma*) derives its name from the presence on the

palpebral conjunctiva of elevations, called *granules*, about the size of a pin's head. The disease is contagious, and occurs as a rule in epidemics,[1] very few sporadic cases being met with.

The symptoms vary greatly, but cases clinically fall into three groups: (1) those described as subacute or chronic, with an insidious onset; (2) acute, few in number, accompanied by much discharge; (3) recurrent or relapsing cases.

(1) In *subacute or chronic* forms, the first *symptoms* the patient complains of are irritability and sensitiveness

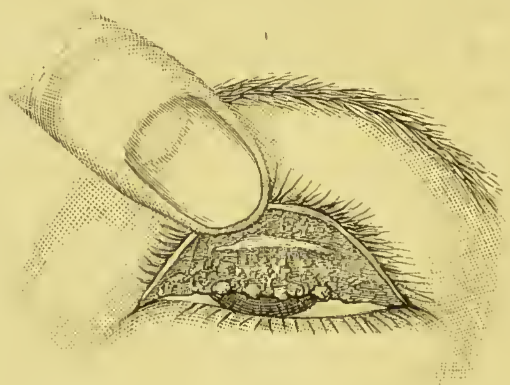


Fig. 16.—Showing the Granules and a Linear Cicatricial Scar above

of the eyes, weariness on reading, feeling of stiffness and heaviness of the lids; there is also lachrymation and sometimes photophobia. The ciliary borders of the lids may be reddened, and dried secretion will often be found at the roots of the eyelashes. On everting the upper lid, the palpebral conjunctiva appears thickened and congested, and at the retrotarsal fold and fornix discrete round bodies of various sizes may be found. These bodies, the granules, are whitish or pink in colour,

[1] For a full description of this disease the reader should consult Dr. Stephenson's excellent treatise on *Epidemic Ophthalmia.*

semi-transparent, and arranged in rows parallel to the posterior border of the tarsal cartilage. The discharge, if present, is mucopurulent, and lasts for an indefinite time. The usual *course* is for the granules to become more and more vascular, associated with increase of the mucopurulent discharge, followed after a time by shrinking and often disappearance of the granules, the discharge becoming less and eventually ceasing altogether. On cessation of the discharge the case is considered to be no longer contagious, notwithstanding the fact that traces of the granules may still be found on everting the upper lid. It is not at all unusual for a relapse to take place while the lids are in this state, in which case the granules increase in size and the mucopurulent discharge reappears.

(2) *Acute granular conjunctivitis* is rarely seen except in severe epidemics. Such cases at first resemble severe mucopurulent conjunctivitis in the severity of the onset; the lids, especially the upper, are red, swollen, and œdematous; the discharge, which at first may be scanty, soon becomes profuse and mucopurulent. On opening the lids the ocular conjunctiva is seen to be congested and swollen, and on everting the lids the palpebral conjunctiva appears red, thickened, velvety in appearance from congestion of the papillæ, and the retrotarsal folds have reddish discrete elevations (granules) on them. As the disease progresses, the swelling of the conjunctiva increases, almost hiding the granules, and at the same time the discharge becomes more profuse. During this acute mucopurulent stage the granules often become absorbed and disappear, and as the inflammation subsides, at a period varying from one to three weeks, the conjunctiva may gradually assume its normal character. In other less favourable cases the disease passes into the chronic form.

(3) *Relapsing or recurrent cases* are those generally met with in an out-patient department.

The *symptoms* are the same as in the first form described.

Signs.—The upper lids are heavy-looking, approaching a condition of ptosis; their ciliary margins are reddened and caked with dry discharge, and the eyelashes are often stunted and misdirected. The palpebral conjunctiva of the lower lid is usually congested and œdematous-looking, with occasionally granules upon it. On eversion of the upper lid the tarsal conjunctiva is swollen, vascular, and sometimes raised into papillæ like velvet pile; the retrotarsal fold and fornix are studded with numerous granulations. These may be small and semi-transparent, large and warty-looking with intervening sulci, or grey and succulent. The tarsal conjunctiva of the upper lid frequently shows linear scars (fig. 16), the result of previous attacks. The ocular conjunctiva very rarely has granules on it, but may become vascular and lose its polish. After repeated attacks the surface of the cornea becomes pitted, dull, and vascularised.

Complications and sequelæ.—A first attack is rarely followed by complications, but after many relapses changes are found in the cornea, conjunctiva, and lids.

Superficial vascular keratitis is a common complication, affecting generally the upper part of the cornea. This superficial ulceration of the cornea is apparently part of the disease, and is not due to abrasion and rubbing of the cornea from the presence of the granules. Combined with this loss of surface is the deposition of a newly formed vascular tissue upon the surface of the cornea, and to this condition the term *pannus* has been applied.

Pannus (*pannus*, cloth) begins at the upper part of the cornea beneath the lid, and extends downwards by a defined border from the periphery towards the centre of the cornea, and may eventually cover its whole area. When the cornea is in a state of pannus its surface

appears uneven, with a greyish transparent look, and is traversed by many small blood-vessels.

As a result of the ulceration and pannus the cornea becomes opaque and nebulous, and occasionally bulges (*corneal staphyloma*); iritis may also ensue.

The palpebral conjunctiva always undergoes hypertrophy, which is followed by superficial cicatrisation, and may result in linear scarring (fig. 16). The fornix being the chief seat of granules, the sulcus or *cul-de-sac* is shortened and sometimes obliterated. In severe cases symblepharon may result, and even essential shrinking of the conjunctiva. The lids are affected partly by the conjunctival cicatrices, and partly by hypertrophy and consequent changes in the tarsal 'cartilages.' The upper lids generally curve inwards, producing entropion and trichiasis; and ectropion may result in the lower lids.

Causation.—Contagion is the exciting cause of granular conjunctivitis, but its spread in the epidemic form is to a great extent influenced by certain predisposing causes.

Thus, it is prevalent in certain races, as the Jews, Irish and Egyptians, and attacks the poor rather than the rich. Bad hygienic surroundings, such as are met with in insanitary schools, overcrowded camps (*military ophthalmia*), prisons and barracks, favour the propagation of the disease. In hilly countries it is almost unknown, but prevails in low-lying districts, especially near a river.

Pathology.—In granular conjunctivitis two conditions are met with: (1) increase of the papillæ of the conjunctiva; (2) the presence of masses of lymphatic tissue (the granules). The latter consist of rounded aggregations, forming follicles resembling those of Peyer's glands.

When these follicles have existed some time, they appear to acquire a capsule of connective tissue. Part of the lymphoid cells become changed into spindle cells and transformed into connective tissue, and from the

contraction of this connective tissue many of the sequelæ of trachoma result.

Two views are held as to the nature of the granules: (*a*) that they are due to hypertrophy of the lymph follicles of the conjunctiva; (*b*) that they are new growths. A specific micro-organism has been described as the exciting cause, but this is very doubtful.

Prognosis.—In the first stage of the complaint a cure may be made by careful hygienic measures; but when the disease is well established the prognosis is unfavourable, as there is always a risk of recrudescence.

Treatment must be directed towards producing absorption of the granules, taking care not to destroy the mucous membrane. In chronic cases astringents, such as sulphate of zinc drops (F. 17), may be used if there be mucopurulent conjunctivitis. The eyes must be kept free from discharge by lotions, such as boracic acid (F. 24) or perchloride of mercury (1 in 6,000). If the granules be much raised the best treatment is to paint them with silver nitrate solution (gr. x–℥j). This is done by everting both lids, so that they meet and cover the cornea. The surface of the lids is dried by a pad of absorbent cotton-wool, and the palpebral conjunctiva is then painted with a camel's-hair brush, or a probe covered with absorbent cotton-wool soaked in the silver solution. A weak solution of common salt is dropped on the lids, forming chloride of silver, which prevents the further caustic action of the silver salt. If the granulations be œdematous-looking and there is not much discharge, the palpebral conjunctiva may be rubbed over with a crystal of sulphate of copper, and the lids sponged afterwards with cold water.

Other methods of treatment consist in excision of the granules, squeezing them out between the thumb-nails, or scraping them with a spoon. The fornix of the conjunctiva, being the most common seat of the granules,

has occasionally been excised; infusions of jequirity (F. 49) are sometimes employed.

For cases of severe pannus, Critchett introduced the operation known as *peritomy* (περί, around, τέμνω, I cut). It is performed by removing with a pair of scissors a ribbon or strip of conjunctiva and subconjunctival tissue, about two and a half lines in width, around and up to the corneal margin. The object of this operation is to cut off the supply of blood-vessels to the cornea.

Precautions.—As the disease is contagious, at all events during the mucopurulent stage, it is necessary that extreme care should be taken to prevent it from spreading. Epidemics in England have been chiefly confined to Board schools, and evidence tends to show that the spread of the infection is due chiefly to the washing and bathing arrangements and the general hygienic conditions.

It is important in such schools that the ventilation of the building should be efficient, the sanitary arrangements perfect, and the general health of the children carefully looked after. Basins, baths, towels, handkerchiefs and other linen are the chief agents through which the contagion is spread. The lids of all children and attendants ought to be examined from time to time, and special care exercised on the admission of new pupils. Every child suffering from granular lids accompanied by discharge must be isolated at once and put under proper medical treatment and nursing, till the discharge has ceased and the granules have quieted down. But the question of how long a child is contagious can only be settled on the merits of each individual case after examination by an expert.

Phlyctenular conjunctivitis (Φλύκταινα, bladder) (fig. 17) is a limited inflammation, characterised by the presence on the ocular conjunctiva of one or more small elevations (*phlyctenules*), each as a rule, surrounded

by a vascular zone. This limited inflammation distinguishes phlyctenular from other kinds of conjunctivitis, and persists for a time after the phlyctenules have disappeared.

The elevations may be single or multiple, and it may be said generally, that the fewer in number the larger their size, and *vice versâ*.

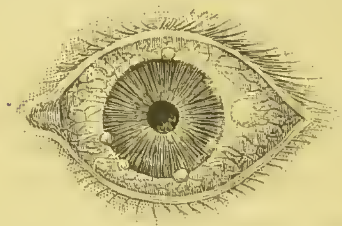


Fig. 17.—Phlyctenular Conjunctivitis

The *symptoms* are rarely well marked, and may be absent altogether, the first intimation of the disease being often obtained from a looking-glass or from a friend. There may be a feeling of grittiness or smarting pain in the eye, with increased lachrymation and sometimes photophobia. The lids stick together during sleep, and a little dried discharge collects at the roots of the eyelashes. The ocular conjunctiva is congested in pinkish vascular patches, but if there be many phlyctenules the conjunctival congestion may be general. In the centre of each vascular patch a portion of the conjunctiva is raised and generally whitish-looking, and this elevation is the phlyctenule.

It tends to increase slightly in size, and may disappear altogether, leaving the congested conjunctival patch to mark its original seat ; or the apex may give way, producing an ulcer of the conjunctiva, which stains green by fluorescin. This ulcer granulates up and leaves no trace of its previous existence. The usual duration of a phlyctenule is from a day to a week ; in children they appear in crops, and relapses are very common. In adults, a large solitary phlyctenule, with its characteristic vascular patch, is often difficult to diagnose from episcleritis (p. 98), but the inflamed area of conjunctiva is not so large and the congestion not so deeply situated.

Notwithstanding the fact that severe conjunctival inflammation may accompany this disease, it is very rare for any permanent injury to be done to the eye. Owing to the anterior epithelium of the cornea being continuous with the conjunctival epithelium, phlyctenules may be found on the cornea (p. 71) and conjunctiva at the same time. Ciliary blepharitis and an eczematous condition of the face are not infrequently present.

Causation.—It is the most common eye disease in children, and occurs amongst both the rich and poor. It is closely related to errors of diet, bad hygienic surroundings and a tubercular diathesis. It is often a sequela of measles, whooping cough, and scarlet fever. The disease is frequently met with in patients with errors of refraction, as hypermetropia or astigmatism.

Pathology.—Phlyctenules originate as a small cell infiltration beneath the epithelium layer of the conjunctiva, corresponding to papules in other parts, as the skin. They are solid and not vesicular, as often described.

The conjunctival epithelium being raised by the proliferation and pressure of these small cells, tends to break down at the apex of the phlyctenule, thus setting free the inflammatory cells, and leading to the formation of an ulcer with a depressed centre. Occasionally the phlyctenules become pustular (*pustular conjunctivitis*).

Treatment.—The presence of phlyctenules is always associated with some upset of general health, and careful inquiry must be made, especially in children, as to errors in diet, clothing, and hygiene. My own experience is that small doses of arsenic for a week, followed by tonics, as iron and cod liver oil, are of great benefit, and the bowels must at the same time be carefully regulated.

The eye should be kept clean by weak lotions, as boracic acid (F. 24), and by applying one of the follow-

ing antiseptic irritants: yellow oxide of mercury ointment (F. 40) or powdered calomel once a day. To use the ointment, a small piece as large as a hemp seed should be taken up on the tip of the clean finger and placed on the conjunctival surface of the everted lower lid. Such application is made more efficacious by rubbing gently the upper lid over the eyeball, and thus distributing the ointment uniformly.

The best way of applying the calomel is to place the drug, finely powdered, in the angle made by folding a piece of paper once, and, opening the eye, to blow in the powder.

Spring conjunctivitis (*vernal conjunctivitis*) is a chronic disease affecting males as a rule, and though often met with on the Continent, is rare in England. It is characterised by the presence on the palpebral and ocular conjunctivæ of broad, flattened, soft-looking elevations, which may be mistaken for those of granular conjunctivitis. The symptoms are a feeling of heaviness in the upper lid, lachrymation, photophobia, and frequently smarting pain and irritability in the eye.

The lids are swollen, and may be pushed forwards by the growths which are found as a rule on the palpebral conjunctiva of the upper lid, and on the ocular conjunctiva near the limb. They are very persistent, may last for several years, and though of considerable size, do not tend to invade the cornea to any extent. The overlying conjunctiva presents a bluish-white appearance, which has been compared to skim milk.

After several recurrences they tend to disappear, leaving no trace of their presence, and in this way form a contrast to the granules of granular conjunctivitis.

In the spring and warm weather the symptoms, which have been latent during the cold months, reappear, and continue till the autumn.

The *treatment* is the same as that for mucopurulent

conjunctivitis, but excision of the growths is sometimes indicated.

Pinguecula (*pinguis*, fat) is a yellowish elevation of the ocular conjunctiva, and is found in adults over thirty years of age. It is situated to the outer or inner side of the cornea in the most prominent and exposed portion of the conjunctiva. It is probably formed by the opening and shutting of the lids producing a fold of the conjunctiva corresponding to the palpebral fissure. By the closing action of the lids, any irritants, as foreign bodies, would be liable to be pushed on to this portion of the conjunctiva. A pinguecula consists of hypertrophied conjunctival epithelium and connective tissue without fat, and is generally regarded as a normal structure of adult life.

Pterygium (πτέρυξ, wing) (fig. 18) is a triangular thickened fold of the ocular conjunctiva, situated within the area of the palpebral fissure, generally at the inner or nasal side of the cornea, but may be on the outer side, and in one or both eyes. It is associated with, and probably depends on, well-developed pingueculæ, and, like these, occurs in adults over 30.

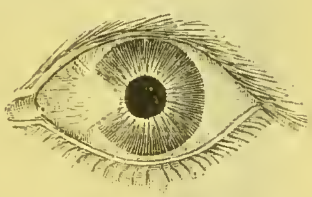


Fig. 18.—Pterygium

It is seldom found except in those who have lived in the tropics, sailors, and people employed in dusty occupations, being especially liable to the disease. The growth varies from a red vascular fleshy mass to a structure presenting the appearance of normal conjunctiva. By its apex the pterygium is attached to the cornea, whilst the broad conjunctival base extends as far as the canthus. The portion near the limb of the conjunctiva is often free, and in this recess, and under the superior and inferior folds or borders, the bacillus of xerosis has been found, and has been credited with the growth of the pterygium. Its position at the most exposed portion

of the conjunctiva points to its origin being due, like a pinguecula, to irritation of the surface of the conjunctiva, and also of the limb of the cornea. Owing to irritation by foreign bodies, and probably to ulceration of the cornea, the thickened conjunctiva of the pinguecula folding itself over towards the cornea like a bridge, becomes adherent to the anterior surface of the cornea, and so is engrafted there. It afterwards tends to grow towards, but not beyond, the centre of the cornea.

The *treatment* in a case of growing pterygium is to remove the structure from the cornea. This is done, under cocaine, by grasping the central and generally non-adherent portion with a pair of fixation forceps (fig. 19), and then dissecting the growth from the cornea with a Beer's knife (fig. 20) towards the attached base. The apex is turned towards the base and stitched into the conjunctiva there. The object of this operation is to induce the pterygium to grow in the opposite direction.

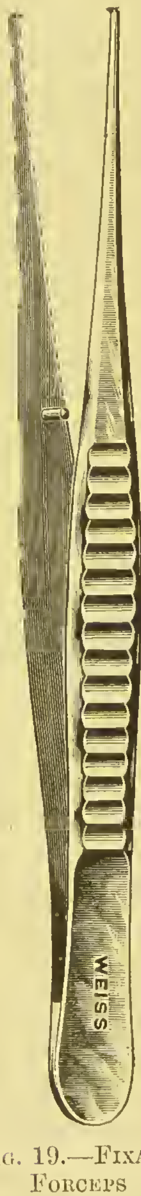


Fig. 19.—Fixation Forceps

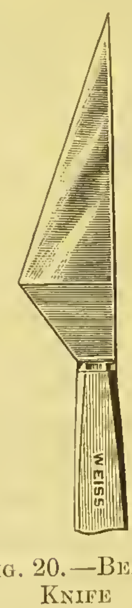


Fig. 20.—Beer's Knife

Xerosis (ξηρός, dry) of the conjunctiva is an objective symptom, characterised by a dry and usually shrivelled condition, which may be either

localised or general. The dried patches are opaque, white, or grey; their surface is roughened, and covered by epithelial *débris*, scales, or by white bubbles like scum; and they are not moistened by the tears. From these dry patches a small bacillus, in great numbers, may be obtained, and is known as the bacillus of xerosis. This condition occurs as (1) a sequela of the cicatricial changes in the conjunctiva, following essential shrinking, pemphigus, trachoma, and injuries (burns and scalds); (2) from exposure (ectropion, lagophthalmos, Graves' disease); (3) atrophic change, in keratomalacia and functional night blindness.

Pemphigus of the conjunctiva.—In general pemphigus bullæ have been found on the conjunctiva coincident with their appearance on the skin and other parts of the body; cicatrisation of the conjunctiva and the subconjunctival tissue has followed. In other cases, where there is a definite history of general pemphigus without the conjunctiva at the same time being affected, cicatrisation has followed with essential shrinking of the conjunctiva.

The disease occurs at all ages, and treatment produces no benefit.

Essential shrinking of the conjunctiva.—Occasionally, with or without signs of chronic inflammation the whole conjunctiva contracts and cicatrises; this happens sometimes as a sequela of granular conjunctivitis, with the result that the conjunctival sac is diminished and even obliterated by adhesion of the lids to the eyeball.

The remains of the conjunctiva assume a dry and shrivelled character, and the cornea tends to develop into a hard, dry, and opaque membrane.

Amyloid disease of the conjunctiva occurs very rarely, and seems to be restricted to Russia and the adjacent countries. It is characterised by yellowish waxlike non-vascular patches on the conjunctiva.

TUMOURS OF THE CONJUNCTIVA are of rare occurrence, and may be divided into inflammatory and new growths.

Inflammatory tumours.—*Non-infective granulomata* are small pedunculated tumours generally due to injury or operations. They are seen after tenotomies, and sprouting from burst Meibomian cysts.

Infective granulomata.—Syphilis is met with in the conjunctiva either in the early or late stage of the disease. A primary sore may be acquired by kissing, and by removing foreign bodies from the eye with the tongue; the preauricular and submaxillary glands become greatly enlarged. As a rule there is no permanent damage done to the structures of the eye itself.

Lupus of the conjunctiva is generally secondary to the growth on the eyelid, but occasionally arises primarily. It is very soft, with a tendency to bleed, and progresses slowly, having a well-defined margin, and occasionally producing pannus and ulceration of the cornea. The disease may be either scraped away with a spoon or cauterised with solid nitrate of silver. *Tubercle* of the conjunctiva may be included under 'lupus,' and *leprosy* and *vaccinia* are rarely met with.

New growths.—Innocent.—*Dermoid* is a smooth, firm, yellowish-white tumour of congenital origin, generally situated near the corneal limb, and though usually invading the cornea, may be wholly on the conjunctiva. On its surface are a few downy hairs. *Treatment* consists in removal by dissection.

Papillomata with narrow pedicles or sessile may be found on either ocular or palpebral conjunctiva, and should be removed.

Single transparent *cysts* occur occasionally. A cystiform dilatation of the lymphatic vessels is not uncommon, and frequently assumes a moniliform shape (lymphangiectasis of the conjunctiva).

Malignant.—Primary malignant tumours of the conjunctiva are either epithelioma or melanotic sarcoma, and have their origin at the corneal limb. If small, they should be removed as freely as possible, and the site of the disease cauterised; if large, it is necessary to remove the eyeball and perhaps even the contents of the orbit.

Staining of the conjunctiva occurs from jaundice, aniline dyes, nitrate of silver, and from extravasated blood. Permanent staining from *silver nitrate* is seen after its long-continued use in granular conjunctivitis. The ocular conjunctiva assumes a yellowish or brown colour, and the palpebral a slaty purple tint; this appearance is due to staining of the elastic fibres of the subepithelial layer.

Blood-staining may occur from a burn or injury to the conjunctiva, but is generally due to subconjunctival ecchymosis the result of coughing, vomiting, straining, or blows. It is not permanent.

Lithiasis.—In gouty patients, small white concretions giving rise to a sensation of grittiness and lachrymation may be found in the palpebral conjunctiva of both upper and lower lids, and should be removed under cocaine by a sharp needle or by a knife.

INJURIES OF THE CONJUNCTIVA.—**Foreign bodies** such as particles of dust, coal, or metals often find their way into the conjunctival sac, and, in most cases, are washed out by the tears. If a foreign body does not come away in this manner, it is generally found adhering to the palpebral conjunctiva of the upper lid, which must be everted to see it.

The symptoms are lachrymation, pain on movement of the eye, photophobia, and even blepharospasm.

Treatment is to remove the foreign body by a spud (fig. 29) or needle if it is fixed in the conjunctiva, but, as a rule, this may be done by a camel's-hair brush or a finely pointed fold of a soft handkerchief.

Wounds of the conjunctiva are generally due to

lacerations, and if small heal up quickly, but if extensive should be united by stitches, and treated with cold compress and a bandage.

Burns and scalds are caused by quicklime, molten metal, boiling water, or the fumes of acids and alkalis. They must be very carefully treated, as an apparently slight injury may be followed by disastrous results. Those due to quicklime are the most serious, and even a few grains of it may give rise to great destruction. Burns of the conjunctiva have a white or ashy-grey appearance, and are sometimes covered by a shreddy membrane. The effect of destruction of the mucous membrane is to produce an ulcer, which subsequently cicatrises, and frequently leads to symblepharon and alteration in the position of the lid.

Treatment.—Any foreign bodies such as lime or metal should be searched for and removed; the conjunctival sac should be washed out with water or a sedative lotion, and castor or sweet oil dropped into the eye three times a day; the object of the oil is to prevent the occurrence of symblepharon. The eye should be treated with cold compresses and bandaged.

If the burn be due to an acid, the eye should be at once washed out with a neutralising solution, as carbonate of potash; and if caused by an alkali, oil should be instilled. The conjunctival sac must be carefully watched for any slight adhesion between the ocular and palpebral conjunctivæ, and if such be found, it must be broken down daily with a probe.

CHAPTER V

DISEASES OF THE CORNEA

Anatomy.—The cornea, forming with the sclerotic the protective coat of the eyeball, is a transparent membrane with a highly polished surface, and may be compared to a watch-glass, being convex in front and concave behind. It is in shape an ellipse, the vertical height of which is 11 mm., and the horizontal width 12 mm. ; its thickness is only 1 mm., but its texture is very firm and resisting. For all practical purposes the cornea may be described as an avascular structure, though there are small looped vessels beneath the anterior epithelium extending inwards to about 1·5 mm. from its periphery. The structure is composed of (1) the anterior stratified epithelial layer continuous with the conjunctiva, (2) the anterior homogeneous membrane (Bowman's), (3) the corneal tissue proper, forming practically the whole bulk and thickness of the cornea, consisting of connective tissue fibres with numerous branched cells and continuous with the sclerotic, (4) the posterior homogeneous membrane (Descemet's), lined posteriorly by (5) a single layer of epithelioid cells, called the posterior epithelial layer, continuous with that on the anterior surface of the iris. The nutritive supply reaches the cornea through its lymph spaces. There is an extensive nerve-supply, chiefly from the ciliary branches of the nasal nerve; these nerves terminate in a fine network between the anterior epithelial cells, which accounts for the extreme pain and

photophobia in corneal inflammation, especially in superficial ulceration.

KERATITIS (κέρας, horn), or inflammation of the cornea, is characterised by pain, photophobia, lachrymation, impairment of vision, pink circumcorneal zone, and alteration in the natural transparency of the cornea. It may be classified as *superficial*, affecting primarily the anterior epithelial layer; *interstitial* (parenchymatous), implicating the corneal tissue proper; *posterior* (punctate), in connection with the epithelium lining Descemet's membrane; and *general*, including xerotic and neuroparalytic.

Superficial keratitis may be divided into the following varieties: Vascular, phlyctenular, herpetic, bullous, superficial punctate, and dendritic. Under this heading will also be considered corneal ulcers, as they generally commence as a limited superficial keratitis.

Vascular keratitis is the name applied to a general superficial inflammation attended by the presence of numerous superficial blood-vessels; to the condition so produced the term *pannus* is applied (see p. 56).

The *symptoms* consist of defective vision, and irritability of the eye, shown by lachrymation and photophobia.

Signs.—The upper part of the cornea becomes opalescent, and its surface rough and pitted. There is a deposition of newly formed vascular tissue in the superficial layers of the cornea, and the vessels forming it are bright red in colour, of different sizes, and varying in number, occasionally only two or three being present. They can be seen to be continuous with the anterior conjunctival vessels, and consist of trunks dividing into many branches like a tree. Besides these superficial vessels, others from the episcleral may be seen deeper in the cornea. The vessels gradually push their way over the cornea, which tends to become opaque in advance of them. Very often the lower part of the cornea may be

involved in the same way, and thus the whole may become affected. In cases that improve, the blood-vessels tend to clear up from the periphery, leaving the cornea still nebulous; the opacity which remains is generally near the centre, and it is rare for the cornea to become again completely transparent. Iritis occasionally supervenes.

The cause in most cases is granular conjunctivitis, but it may be phlyctenular keratitis, trichiasis, entropion, and ectropion.

Pathology.—The cornea becomes infiltrated with migratory cells at several points, and these cells invade the deeper layers of the epithelium. At a later stage a number of red blood cells are seen running in anastomosing channels which have at first no definite lining. The migratory cells form new connective tissue, and the surface epithelium becomes hyperplastic.

The prognosis, in severe cases, is unfavourable so far as vision is concerned, but in slight cases treatment gives good results. The *treatment* consists in removing any cause, as conjunctivitis, ingrowing lashes, &c., and the local application of calomel or yellow oxide of mercury ointment (F. 40).

Occasionally cauterisation with silver nitrate or copper sulphate does good. If the vascularity be excessive, the operation of peritomy (p. 59) may be performed, or the infusion of jequirity (F. 49) employed.

Phlyctenular keratitis is the most common form of superficial keratitis, and from the continuity of the corneal epithelium with that of the conjunctiva is very frequently associated with phlyctenular conjunctivitis (p. 59). The phlyctenules are at first small whitish or grey elevations, found, as a rule, at the periphery of the cornea, but may be situated anywhere on its surface. They may all be developed at the same time, or occur in successive crops.

The *symptoms* consist of lachrymation, pain, photophobia, and lid spasm.

Signs.—The corneal phlyctenules are at first grey-white and slightly raised, like those of the conjunctiva; the epithelium covering them gives way at the apex and leads to limited ulcers, with infiltration and opalescence of the surrounding cornea. The pain is greatly increased by the ulceration owing to exposure of the nerve endings. In those cases where a phlyctenule is situated at the periphery of the cornea, the congestion is limited to the immediate neighbourhood of the lesion, and so has a patchy appearance, whereas, if the lesion be near the centre of the cornea, the character of the congestion is that of a general circumcorneal zone. The ulcers are generally superficial, and do not tend to spread deeply or widely. In most cases they heal quickly, but sometimes, owing to the general health of the patient, their duration is long; there is a marked tendency to recurrence. In many cases, blood-vessels passing to the ulcer from the conjunctiva produce a red vascular appearance in the floor of the ulcer, which is then termed a *vascular ulcer*. Phlyctenular ulcers give rise on healing to nebulæ, or opacities of the cornea, which may be permanent, but often disappear; they are more fully described under the sequelæ of corneal ulcers.

Causation.—The disease is generally met with in young children, and is associated with bad hygienic surroundings, improper feeding, constitutional diatheses as tubercle, and zymotic diseases as measles, whooping cough, &c. It is prevalent at certain seasons of the year. The *pathology* is the same as that of phlyctenular conjunctivitis.

Constitutional treatment is of the greatest importance, and the best way of carrying it out is to give small doses of arsenic, or grey powder and rhubarb, for a week, followed by tonics such as iron and cod-liver oil. Great

attention must be paid to dietetic details and children should be prohibited from taking much sugar, cakes, and fruit. Hygienic measures are of equal importance.

Local treatment.—For this the yellow oxide of mercury ointment (F. 40) is most effective; calomel and iodoform may also be used. If the ulceration be central or superficial, atropine is indicated, alone or in combination with the yellow ointment (F. 41). If there be much photophobia and lachrymation, shading of the eyes and counter-irritation, in the form of liniment of iodine painted on the brow, give much relief.

Herpetic keratitis (*Herpes corneæ*) is seldom met with in England, and must be distinguished from the ulcers of the cornea associated with herpes ophthalmicus. It is rarely seen under 15 years of age. The disease is characterised by the suddenness of its onset, and the presence on the cornea of a number of small clear transparent vesicles about the size of a pin's head. The vesicles are accompanied by severe pain and neuralgia along the branches of the ophthalmic division of the fifth nerve, by lachrymation, and often by photophobia. As a rule they appear in crops at short intervals, and the ulcers on the cornea, produced by the breaking down of the vesicles, often disappear without leaving any trace of their presence. The tension of the eyeball is reduced.

Causation.—Pneumonia and catarrhal affection of the respiratory tract at times precede the affection, and herpes of the lips and nose is often coexistent.

The disease must be *treated* locally by the yellow oxide of mercury ointment with atropine (F. 41), and if there be much pain, cocaine may be used. The eye should be lightly bandaged and a shade or goggles worn.

Bullous keratitis is a very chronic form, characterised by one or more bullæ on the cornea, with generally a circumcorneal vascular zone; it is accompanied by considerable pain and photophobia. When

a bulla has broken, a large ulcer is produced having an infiltrated base. The disease has been found in cases of uveitis and glaucoma, and is due, according to Leber, to an œdematous condition of the deeper cells of the anterior surface of the cornea. The *treatment* is to cut off with a small pair of scissors the raised portion of the bulla, and then to stimulate the base by painting it with nitrate of silver solution (F. 35), or by dusting iodoform on it. The eye should be lightly bandaged. Hypodermic injections of morphia are often needed to allay the pain.

Superficial punctate keratitis[1] commences with the *symptoms* of acute conjunctivitis, which are followed by the appearance of numerous small grey spots in the superficial layers of the cornea. These spots are not accompanied by vesicles, nor, as a rule, by corneal ulceration, and after lasting many months gradually disappear. The treatment consists of first relieving the conjunctival symptoms by antiseptic or astringent lotions and then applying yellow oxide of mercury ointment (F. 40).

Dendritic (*mycotic*) **keratitis** is characterised by ulceration of the cornea, with numerous greyish lines spreading into the corneal tissue like the branches of a tree. These offshoots lose the epithelium covering them and become furrowed ulcers.

The *symptoms* may be severe or slight, and the *course* is chronic. It is supposed to be due to a special micro-organism. The *treatment* should be by lotions as corrosive sublimate (F. 34), or by scraping the ulcerated surface with a sharp spoon.

Ulcers.—By a corneal ulcer is understood a loss of substance of the cornea, involving necessarily its superficial surface, and undergoing active change. Ulcers have been classified in various ways according to their position, depth, course, cause, vascularisation, and appearance; thus, they may be central or peripheral, superficial

[1] Fuchs' *Textbook of Ophthalmology*, p. 171.

or deep, acute or chronic, primary or secondary, vascular or non-vascular, transparent or opaque.

In this book no attempt is made to give a definite classification of corneal ulcers; the development and course of an ordinary ulcer are first described, and afterwards certain ulcers presenting special peculiarities are noticed.

An ulcer commences, as a rule, by a slight infiltration of the cornea, characterised by limited dulness and opalescence of the corneal substance. This opalescent area becomes limited, slightly raised, and of a grey or yellowish colour. The epithelial layer, anterior to the focus of inflammation, gives way at the most prominent part and thus the ulcer is formed. The surrounding cornea, for a short distance, is generally grey or whitish, and this infiltration area is of importance, as the less it is marked the less likelihood there is of the ulcer spreading, and *vice versâ.* The ulcer may now spread laterally or in depth; if the former, the edges are ragged and irregular. After the area of infiltration has ceased to extend, the preliminary steps towards healing take place; the tissues destroyed are cast off, and the surrounding cornea gradually becomes clear. When the base and sides are transparent, healing ensues, and during the process the edges are seen to become less ragged and more rounded, and eventually to shelve off towards the base instead of appearing undermined. The depression made by the ulcer becomes filled up with new connective tissue, and over this fresh epithelium grows from the edges. Whilst these changes have been taking place, blood-vessels have extended from the nearest part of the limbus to the seat of the ulcer. The new connective tissue filling up the ulcer, not being transparent, produces alteration of colour in the cornea at the seat of ulceration; if the colour be grey the opacity is known as a *nebula,* if dense white, as a *leukoma.* When new tissue

is not formed in sufficient quantities to fill up the excavation made by the ulcer, a depression or facet remains and may be permanent.

The infective ulcer (*hypopyon ulcer*) is due to local infection, and in most cases follows direct injuries of the cornea by pieces of wood or metal. This variety is met with generally in old people, and especially in those whose constitution has been undermined by drink and disease. In many cases it is crescentic in shape (fig. 21), and is to be seen spreading at one border whilst healing at the other (serpiginous). The ulcer has a tendency to increase both superficially and in depth, and is, as a rule, accompanied by pus or lymph in the anterior chamber known as hypopyon.

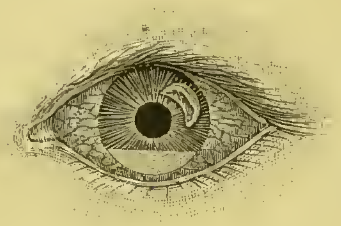


Fig. 21.—Infective Ulcer and Hypopyon

From the lowered vitality of the cornea, most infective ulcers are accompanied by little or no pain, and even half the cornea may be involved before the patient presents himself for advice. In severe cases, perforation may take place, followed by hernia of the iris, and the eye may pass into a condition of panophthalmitis.

The marginal ulcer is occasionally found commencing as a crescent at the periphery of the cornea, especially in broken-down adults and old people, and may be difficult to diagnose on account of an arcus senilis. It has a tendency to extend around the periphery rather than to make its way towards the centre, and may even encircle the cornea.

The transparent ulcer is usually small, superficial, situated in the neighbourhood of the centre of the cornea, and has no tendency to spread. It is as a rule unaccompanied by circumcorneal zone, lachrymation, or marked

opacity of the cornea. It is very indolent, and though during repair the ulcerated edges become covered by new epithelium, a permanent depression is always left.

The *symptoms* found in corneal ulcers vary very much with the age, constitution, and general health of the patient. In all cases, photophobia and pain on exposure to light are the chief subjective symptoms. The pain is due to exposure of twigs of the corneal nerves. In children the attitude is often characteristic : the patient sits in the darkest corner of the room, the head buried in the hands or frock, and the back turned to any source of light; the lids are tightly closed and swollen as if in spasm, and tears stream down the face. In an adult, as a rule, these symptoms are not so extreme.

The chief *signs* are swollen lids, lachrymation, pink circumcorneal vascular zone, which may be masked by extreme conjunctival congestion, a localised loss of surface of the cornea (seen best by *focal illumination*), infiltration of the surrounding cornea, and sometimes blood-vessels passing to the ulcer.

Causation.—Ulcers may be due to injury or disease, and of the former, abrasions of the cornea produced by foreign bodies are frequently the cause; they follow inflammatory affections, such as phlyctenular, herpetic, and bullous keratitis, and may also be secondary to inflammation of the lachrymal sac and conjunctiva, especially purulent and diphtherial conjunctivitis. In children they often occur as a sequela of measles, whooping cough, scarlet fever, and other exanthemata. They are met with frequently in tubercular subjects, in those who are ill-fed, dirty, and exposed to bad hygienic surroundings, and in elderly people broken down in health.

Pathology.—Corneal ulcer may originate in a primary loss of the surface epithelium in traumatic abrasions, or as a secondary loss due to a phlyctenule or an abscess.

In whatever way produced, the ulcer is bounded by

walls of corneal tissue more or less infiltrated with small cells, and this infiltration is greater in ulcers following a corneal abscess. The floor of the ulcer and the active edges are covered with *débris* of cells yielding staphylococci and streptococci.

The hypopyon accompanying an ulcer is produced by micro-organisms, conveyed by the corneal lymphatics to the iris and ciliary body, which set up inflammation of these structures with exudation of lymph cells. In a few cases the pus may pass directly from the ulcer through Descemet's membrane into the anterior chamber.

Complications and sequelæ.—The cornea at the site of an ulcer permanently remains less transparent than normal, but the difference may be almost imperceptible. If the density of the opacity be but slight, it is termed a *nebula*, which may be limited or involve the greater part of the cornea. If it be more opaque, the term *leukoma* is applied. When the corneal tissue has been much weakened by ulceration a *staphyloma* is formed. All such opacities and changes interfere seriously with vision.

In other cases the base of the ulcer has a dark almost black appearance, caused by Descemet's membrane, which may protrude, forming a *hernia of Descemet's membrane*.

If the ulcer be very deep, *perforation* of the cornea may take place, and may lead to the establishment of a corneal fistula or prolapse of the iris.

Anterior polar cataract occurs in infants. In all cases of perforation of the cornea, the anterior chamber is reduced in depth or even lost, and the tension is lowered. The iris tends to come forward and attach itself to the cornea at the seat of perforation, giving rise to the formation of an *anterior synechia* (συνέχω, I hold together), and if, on healing, a marked white opacity remains at the seat of perforation, the condition termed *leukoma adhærens* is produced. In cases of perforation of the cornea, iritis

and even suppuration of the eyeball (*panophthalmitis*) may result.

The *prognosis* must be considered from two points of view—the healing of the ulcer, and the condition of vision after healing. Small superficial ulcers, with marked inflammatory reaction in young people, heal soonest and with the smallest amount of scarring, whereas chronic indolent ulcers, at any age, tend to increase in size and to leave a marked scar. The acuteness of vision after healing depends on the position and size of the scar. A large peripheral scar may give rise to little alteration in the acuteness of vision, whereas a small central opacity may most seriously interfere with sight.

The *local treatment* depends upon the position, condition and nature of the ulcer. Atropine, from its sedative action on the cornea and its power of keeping the iris at rest by dilating the pupil, is the routine treatment in all cases. It is, however, contra-indicated in those ulcers, situated at the periphery of the cornea, which are deep and spreading; for, by producing dilatation of the pupil, atropine would tend to cause anterior synechia and greater risk of prolapse of the iris should perforation take place. In such cases eserine, owing to its power of contracting the pupil and thus removing the iris from the neighbourhood of the ulcer, should be employed. When fomentations are needed in the treatment of corneal ulcer, belladonna (F. 4) is the most useful, since its local action is the same as that of atropine; poppy (F. 39) and hot water fomentations, which may be used in every case, must be adopted in those instances above mentioned, where dilatation of the pupil is contra-indicated. In the acute stage of a corneal ulcer, the main lines of treatment are directed at first to the relief of the pain, photophobia and congestion, to checking the spread of the disease, and afterwards to the prevention of sequelæ. Pain and congestion are best relieved by

sedative drops, as atropine (F. 1) and cocaine (F. 10), and fomentations of belladonna and poppy. If possible, a pad of cotton-wool should be placed upon the closed lids, and a bandage carefully applied, with the object of keeping the lids at rest and preventing their movements from irritating the surface of the ulcer; but if there be much conjunctival discharge, a shade or tinted glasses should be placed over both eyes instead of a bandage. Counter-irritation by blisters or by liniment of iodine painted above the eyebrows often does good, but if the pain be very severe, the application of leeches to the temporal region is indicated.

Photophobia, which is constantly present, is to be treated by counter-irritation, as blisters or setons (see Appendix) behind the ear; in young children the sudden application of cold water by means of a sponge or douche to the back of the neck often gives relief.

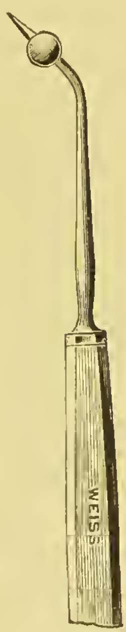


FIG 22.—ACTUAL CAUTERY

If the ulcer tends to spread, the eye should be washed out with some antiseptic solution, as boracic acid (F. 24), Condy (F. 33), silver nitrate (F. 35), or corrosive sublimate (F. 34). Care must be taken against the use of solutions containing lead, as a white deposit may be formed at the site of the ulcer, giving rise to a dense leukoma; solutions of alum are also contra-indicated, as alum is said to dissolve the connective tissue of the cornea, and thus to cause the ulcer to spread. If a slough form on an ulcer, it may be scraped away by a spoon or burned by the cautery. For an *infective ulcer* the best treatment is destruction of its base and edges by the actual cautery (fig. 22), and failing this, by the application of silver nitrate,

either in a strong solution (gr. x–℥j) or in the solid form, or by pure carbolic acid.

In an adult, if hypopyon be present, the pus should be evacuated by paracentesis of the anterior chamber, and the ulcer cauterised at the same time. Paracentesis may be performed either through the base of the ulcer, or on some healthy part of the cornea. For *chronic ulcer*, local stimulation is necessary, and may be carried out by placing in the eye a small quantity of the yellow oxide of mercury ointment (F. 40) every night in the manner already described under Phlyctenular Conjunctivitis. Calomel or iodoform may be dusted on the ulcer, and a watery solution of tincture of opium (1 in 5) may be dropped into the eye. In very indolent ulcers the best results are obtained by the actual cautery.

Cauterisation.—The eye having been brought under the influence of cocaine, the patient is placed in a recumbent position; a speculum is introduced between the lids, and the actual cautery (fig. 22), heated to a dull red in the flame of a spirit lamp, is applied to both the base and edges of the ulcer. A little castor oil is then dropped into the eye, and a bandage applied. Another method of treatment is painting with nitrate of silver (gr. x–℥j).

In ulcers threatening to perforate, paracentesis is indicated, and may be repeated several times if necessary.

Paracentesis of the anterior chamber is performed whilst the eye is under cocaine (in children a general anæsthetic must be used). The patient lying down and a speculum (fig. 23) being introduced between the lids the operator, seizing the eye by fixation forceps (fig. 19), or fixing it by means of his fingers, passes a broad bent cutting needle (fig. 24) or a keratome (fig. 33) through the lower part of the periphery of the cornea, into the anterior chamber, and so lets out the aqueous humour. If the aqueous does not escape readily, it may be necessary to press with a curette (fig. 25) on the lower lip of the wound

to enable it to do so. After the operation it is very important to be certain that the iris is in position, as otherwise prolapse may result.

Saemisch's method of treating a deep spreading ulcer is to divide it with a Graefe's knife (fig. 57), and by this means the tension of the swollen cornea is relieved. This is done, if possible, whilst the eye is under the influence of cocaine, but in cases where active inflammation is present the drug has little effect, and general anæsthetics must then be employed. The lids being held open by a speculum and the eyeball fixed by the forceps, the knife

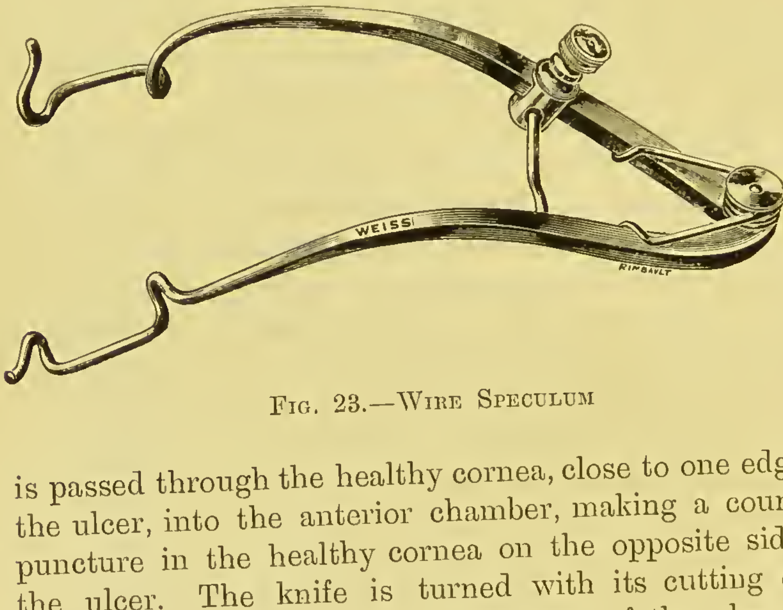


Fig. 23.—Wire Speculum

is passed through the healthy cornea, close to one edge of the ulcer, into the anterior chamber, making a counter-puncture in the healthy cornea on the opposite side of the ulcer. The knife is turned with its cutting edge forwards, and made to divide the base of the ulcer and to cut its way out. The aqueous humour and any pus in the anterior chamber are now evacuated, and a bandage applied.

When spontaneous perforation has taken place, atropine or eserine is instilled into the eye according to the position of the ulcer, and pressure by means of a bandage should be applied, or the eye covered up by isinglass plaster.

The *general treatment* is mainly directed to improving the health of the patient, as corneal ulcers, except from traumatic causes, never occur in persons in a good state of health. In children, this is most advantageously done by prescribing alteratives, as arsenic or grey powder and rhubarb, for about a week, and following up this treatment with tonics, such as iron, quinine, and cod-liver oil.

In adults, tonics must be given, and care taken to improve digestive troubles. A complete change of air

Fig. 24.—Bent Needle

Fig. 25.—Curette

and scene is frequently very beneficial. Patients must be well clothed, properly fed, and take sufficient exercise in the fresh air. Small doses of opium are very useful in painful inflammatory ulcers.

Treatment of corneal nebulæ is mainly directed to their absorption, and the best way to procure this result is to apply to the eye an ointment of yellow oxide of mercury (F. 40) every night. It is important after using this

ointment that the lids should be rubbed gently over the eyeball from side to side and from above downwards, for a time varying from half a minute to two minutes. Calomel may also be used, and electrolysis is said to be beneficial.

Iridectomy in cases of central, and even in extensive nebulæ and leukomata, may be performed behind a transparent portion of cornea to improve the vision. Anterior synechiæ may be divided if they cause any trouble.

Tattooing the cornea is practised in order to remove the unsightliness of a corneal leukoma, or to improve the sight in cases of corneal nebulæ which do not cover the whole pupillary area; in these latter cases the irregular diffusion of light through the nebula diminishes the acuity of vision and this is corrected by tattooing.

Operation.—The first steps are to prepare the staining fluid by rubbing Indian ink into a paste with water. The eye being under the influence of cocaine, a speculum (fig. 23) is introduced between the lids, and the eye held by fixation forceps (fig. 19). A number of superficial punctures are then made by a grooved needle (fig. 26), or by De Wecker's multiple tattooing needle, in the leukomatous patch. This is followed by hæmorrhage, which must be checked, and afterwards the black paste well rubbed into the punctures by a spud or the back of a curette. The operation has usually to be repeated several times, and the result is not permanent.

FIG. 26.—GROOVED NEEDLE

Transplantation of the cornea of a rabbit has been attempted in cases where vision has been destroyed by an opacity of the cornea, but without any good results, chiefly because the transferred cornea becomes shrunken and opaque.

Abscess of the cornea is a circumscribed collection of pus in its substance, bounded in front and behind by healthy layers; the surface of the cornea over the abscess is smooth though dull. It is yellowish white in colour, circular in shape if situated near the centre, but crescentic if at the periphery, and it is surrounded by haziness of the cornea. At first the surface over the abscess is raised, but afterwards flattened owing to softening of the corneal tissue.

It is accompanied by pain, frequently intense along the supraorbital and nasal nerves, and photophobia; there is swelling of the lids, conjunctival and episcleral congestion, and œdema of the conjunctiva. Hypopyon and iritis are often present. The *course* is very slow; absorption occasionally takes place, but more often the superficial corneal layers give way, forming an ulcer which leaves permanently some opacity of the cornea. The *prognosis* is practically that of a corneal ulcer. The *treatment* consists of fomentations and bandaging; the abscess, if large, should be incised, and its cavity scraped or cauterised.

Corneal fistula is a small opening in the cornea communicating with the anterior chamber, and from which the aqueous humour is continuously oozing. The condition is met with after wounds and perforating ulcers; it appears as a small dark dot (the orifice) in the centre of a depression. The cornea immediately surrounding the orifice is opalescent, the anterior chamber shallow or absent, and the tension diminished. The pupil is generally contracted from the diminution of intra-ocular tension, and the iris tends to become adherent at the fistulous opening.

The escape of aqueous can be demonstrated by first applying cocaine and drying the cornea with a piece of blotting-paper, whilst the eyelids are kept open, when a drop of fluid will be observed exuding from the fistula. The

treatment consists of the instillation of atropine or eserine, according to the site of the perforation, and the firm application of a bandage. The edges of the fistula may be touched with a fine point of nitrate of silver or the actual cautery. A good plan, if there be no signs of suppuration in the ulcer, is to strap up the eye firmly with isinglass plaster for a period of two or three days to a week.

Interstitial (*parenchymatous*) **keratitis** is a chronic inflammation commencing in the corneal tissue proper, and as a rule exhibiting no tendency to superficial ulceration or to the formation of pus.

Signs and symptoms.—The disease may commence in two ways, either as a haziness of the cornea, or else as a vascularised patch at the periphery (the salmon patch of Hutchinson). Most cases begin with a diffused haziness near the centre of the cornea. On magnifying this patch it will be found to be composed of several small cloudy areas, whilst the anterior surface of the cornea remains smooth and polished. These islets tend to coalesce, and in the course of a few weeks or less the cornea becomes densely opaque resembling ground glass, some parts of it having often a yellowish-white appearance like lymph. At first a pink circumcorneal zone is seen, assuming, as the corneal symptoms become more severe, a deeper hue, characteristic of scleral inflammation or congestion. There is often photophobia and a good deal of neuralgic pain; vision is gradually reduced and may only amount to perception of light.

Course and progress.—After a period varying from a few months to a year, the cornea clears up from the periphery towards the centre, the central part being the last to acquire transparency. In mild cases, the cornea may occasionally become quite transparent, but as a rule more or less haze remains for years or is permanent.

In severe cases, after the ground glass stage, the corneal tissue proper is invaded throughout by new blood-vessels from the anterior ciliary, and assumes the salmon-coloured character spoken of above.

Some cases commence by a small vascular crescent, generally at the upper half of the cornea. On magnifying this zone it is found to be composed of a close network of blood-vessels. The cornea immediately below this patch acquires a hazy appearance, which tends to spread gradually towards the centre, and as a rule to invade its whole area. The vascular crescent slowly increases and may extend and follow in the wake of the corneal opacity. The tissue of the cornea itself softens, and the normal curve becomes exaggerated. The disease begins in one eye, though the other eye is generally at some time affected. After, as a rule, a short interval the second eye becomes implicated, usually before the disease in the first eye has disappeared. If the attack in the first eye be very severe, the course and progress in the second eye is much less marked. Recurrence of the disease rarely takes place.

Complications and sequelæ are iritis, choroiditis, cyclitis, occlusion of the pupil, secondary glaucoma, and shrinking of the globe. After an attack there are generally permanent nebulæ in the cornea, and always the remains, at the corneal periphery, of the vessels of inflammation.

Causation.—The disease usually occurs between the age of five and puberty, and is rarely observed after 30 years. It affects both sexes, and perhaps is more frequently seen in females. Most cases have a history of congenital syphilis (68 per cent., according to Nettleship), though there are many in which no such history can be traced. It is also found in tubercular subjects and very rarely in cases of acquired syphilis.

As interstitial keratitis is so often associated with

congenital syphilis, some of the following signs and symptoms of that disease are generally to be found.

Signs of hereditary syphilis.—The physiognomy is characteristic. The skin is flabby and coarse; the conformation of the skull exhibits a square forehead with prominent frontal eminences and a furrow above the eyebrows. There is a depressed and widened condition of the bridge of the nose, and radiating scars about the angles of the mouth (Hutchinson's lines), and in the mucous membrane of the buccal cavity and pharynx. The teeth are dwarfed, narrow from side to side, their angles rounded off, presenting a 'pegged' appearance, and often there is a crescentic notch in the biting edge. Those generally affected are the incisors of the second dentition. There may be nodes on the bones, and enlargement of lymphatic glands. These patients are frequently deaf, and in some there is a history of 'snuffles,' and a coppery rash about the buttocks soon after birth.

Pathology.—There is a dense infiltration of exudation cells into the deeper layers of the corneal tissue proper, together with many blood-vessels, leading to increased thickness and softening of the cornea. The stress of the inflammation in these cases is borne by the deeper layers of the cornea, and in consequence the anterior portion of the uveal tract becomes implicated, shown by cyclitis, iritis, and choroiditis.

Prognosis.—In the most severe cases, there is generally a chance of some improvement, even after many months or years, as far as vision is concerned. In slight cases the prognosis is good, as the cornea may become almost completely transparent again; and even when vision has been reduced to perception of light the patient has recovered with useful sight.

Diagnosis.—The salmon-coloured vascular patches of interstitial keratitis may be easily mistaken for pannus

but on carefully examining with a magnifying glass, the vessels are seen to be smaller, more uniform in size, and divide into trunks almost parallel to one another (broom-like); they do not spread like the branches of a tree, nor can they be traced directly from the conjunctiva as in pannus. The epithelium over the patches is smooth and not, as a rule, pitted, though there is often a sand-paper appearance of the superficial surface.

Treatment.—Whilst the disease is progressing, the *local* treatment consists in protection of the eyes from light, by means of shades or tinted spectacles, and the instillation of atropine. Afterwards, it must be directed to clearing the corneal tissue by means of absorbents, as yellow oxide of mercury ointment (F. 40), alone or in combination with atropine (F. 41). Calomel may also be used. These remedies must be persevered with for months or years. When the cornea is vascular and shows signs of softening, pressure is to be applied by means of a firm bandage, and in still more severe cases, paracentesis of the anterior chamber may be performed to relieve the bulging.

In adults, the *constitutional treatment* is a mild course of mercury or iodide of potassium, and general attention to the health of the patient. If the disease be associated with anæmia, iron is indicated in combination with the mercury. In children, grey-powder, syrup of the iodide of iron, and cod-liver oil are all useful; but constitutional treatment has little influence over the course of the disease.

Punctate keratitis (*posterior keratitis, Descemetitis*) is characterised by the presence of dots of different sizes on the epithelium lining the membrane of Descemet; these dots consist of migratory cells and proliferation of this epithelium. The condition is really a *symptom* of diseases of the uveal tract, being found in iritis, cyclitis, uveitis (especially the sympathetic

orm), but never as an inflammation of the cornea alone.

The dots (fig. 27) are often arranged in the shape of a conical bullet with the apex upwards near the centre of the cornea. In some cases they change their position with the movements of the patient's head, especially if the position is maintained for a long time, as during sleep. This characteristic shape of the deposit is due to the fluids of the eyeball circulating through the pupil, and bringing with them epithelial deposits and cells which are thrown upon the posterior epithelium of the cornea.

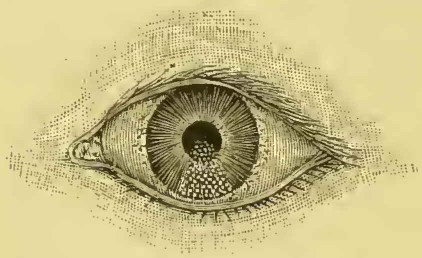


Fig. 27.—Punctate Keratitis

Xerotic keratitis (*keratomalacia*) is a condition resulting from exposure of the cornea owing to insufficient protection by the lids, and is always associated with debilitating causes.

It occurs in children during the last stages of tubercular meningitis and infantile diarrhœa, when it is usually a precursor of death. In Russia, it is met with in children from insufficiency of nutrition during seasons of fasting, and is then preceded by hemeralopia and the dry patches of the conjunctiva found in functional night blindness. In adults, the condition occurs in the course of Graves's disease.

Signs.—The lower half of the cornea becomes steamy, and afterwards grey and infiltrated. A marginal ulcer may now form and tend to perforate, giving rise to prolapse of the iris. Dryness of the cornea sets in, its epithelial surface becomes flaky and peels off, especially near the site of the ulcer, and the whole cornea assumes a yellow crusted horny appearance. There is very little

pain, and one or both eyes may be involved. *Treatment* usually has little effect on the disease; warm fomentations and antiseptic lotions may be used.

Neuroparalytic keratitis is the name given to the changes in the cornea occurring after paralysis of the ophthalmic division of the fifth cranial nerve. These changes were at first said to be trophic, but are, like xerotic keratitis, due rather to exposure. Owing to the corneal anæsthesia, foreign bodies may remain on that membrane for some time, and give rise to ulceration. The *treatment* is to keep the lids closed by means of a bandage or by a suture.

BULGINGS OF THE CORNEA. 1. **Staphyloma** (σταφυλή, bunch of grapes) of the cornea is the name applied to a bulging cicatrix which develops occasionally after corneal ulceration and perforation. It is the result of intra-ocular pressure upon the freshly formed connective tissue which has filled up the gap left by the destruction of the cornea.

Staphyloma may be complete or partial; when *complete*, it is bounded all round by the corneal margin of the sclerotic, and when *partial*, it occupies a limited area within this boundary. The shape of a staphyloma varies, being globular, hemispherical, conical, or lobulated; from the last form the name is derived. In the conical variety the apex of the cone may be either centrally or laterally placed. The colour may vary from dense opaque white to slaty blue, or even black, and there are generally some blood-vessels coursing over the surface. A staphyloma may be so large that the lids cannot cover it, and the upper lid tries to adapt itself to the shape of the bulging.

The development of a staphyloma is usually not attended by much pain, unless it be rapid. All forms are liable to recurrent attacks of inflammation, and to spontaneous or traumatic rupture. Staphyloma is not as a rule composed of the different layers of the cornea, but

of new connective tissue, of which the iris forms the chief part. The lens is often absent, having escaped at the time of perforation, and in most cases it is opaque and shrunken. The changes found in the rest of the eye are mainly the result of increased intra-ocular tension, such as excavation of the optic nerve, and atrophy of the choroid and retina.

Treatment.—In cases of partial staphyloma, an iridectomy may, by reducing tension, check the progress, and at the same time may serve for optical purposes, if there be a clear portion of the cornea left. Another method is excision of an elliptical piece from the apex of the staphyloma, combined with union of the cut edges by sutures. In complete staphyloma, excision of the eyeball may be performed, or abscission.

2. **Conical cornea** (*keratoconus*) is a bulging of the central portion of the cornea, not due to active inflammatory change. It is probably the result of a combination of causes, of which increased intra-ocular tension, weakness of the central portion of the cornea, and subsequent malnutrition are the most important factors.

Symptoms and course.—The eye first becomes myopic, and generally astigmatic, and this latter condition is complicated from the fact that the refraction is altered at first only in the central part of the cornea. The details of the disc and fundus, if seen, appear to be distorted, and vision is much affected even in the early stages. A slight degree is very difficult to detect, but well-marked cases, as in the diagram (fig. 28), are easily recognised. A case of conical cornea usually tends to increase, and when the cone is very prominent its apex becomes cloudy, and a nebula is formed. The progress of such cases is slow;

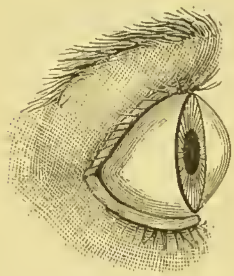


Fig. 28.—Conical Cornea

the majority are found in females between the ages of 10 and 25, and generally both eyes are affected. Conical cornea may follow a central ulcer.

The methods of *diagnosing* the condition are, first, by the direct distant ophthalmoscopic examination, when the shadow appears very ill-defined over the apex of the cone, and plays irregularly over the rest of the cornea, giving rise to an appearance like vortex rings. Secondly, by focal illumination, when the distortion of the corneal reflex can be observed. A third method is by *Placido's disc*, which consists of a circular piece of cardboard on which are painted alternate concentric circles of black and white, with an aperture in its centre for a sight-hole. It is used by being held close to the cornea, and the reflex produced by it on the corneal surface is seen to be distorted, especially if the disc be rotated slowly. *Treatment.*—If the case be slight the refraction must be carefully estimated, especially for astigmatism, and weak solutions of eserine and pilocarpine may be employed for the purpose of diminishing tension; over-use of the eyes must be avoided, particularly for near work. If the case cannot be benefited by glasses, operative measures may be employed. These are paracentesis of the anterior chamber repeated every day for a week, or removing, cauterising, or trephining the apex of the cone. The general health must be carefully attended to.

Arcus senilis is the term applied to a narrow grey, white, or yellowish band, about 1 to 2 mm. broad, near the periphery of the cornea. It is always separated from the periphery by a clear or less opaque zone of corneal tissue, and this distinguishes it from the scars of peripheral ulcers. It commences as two crescents, one at the upper and the other at the lower part of the cornea, and may eventually form a complete ring, but the upper and lower portions are always broader than the lateral. The change consists in a colloid or hyaloid

degeneration of the superficial layers of the corneal tissue behind the anterior elastic lamina. The presence of arcus senilis indicates no organic change, and has no prejudicial effect on corneal operation wounds. It is generally met with after 40, but may be found in young people.

Bloodstaining of the cornea.—In cases of hyphæma following an injury, blood may sometimes be found in the substance of the cornea, and Collins has described a greenish or rusty-brown discoloration of the cornea, after hæmorrhage into the anterior chamber, and found that the pigmentation was due to hæmatoidin.

Transverse calcareous film of the cornea.—A grey band is occasionally found in that part of the cornea which is most often uncovered by the lids. It is situated in the front layers of the corneal tissue proper, the anterior epithelial surface of the cornea being perfectly smooth. On removing the anterior epithelium, the deposit is found to consist of gritty particles. The affection is met with in people over 60 years of age; it tends to progress, but does not spread beyond the cornea. Owing to its position the vision is much interfered with.

The *treatment* consists in removing the anterior epithelium and scraping away the calcareous film about the centre of the band, so as to obtain a transparent area, and the optical result may be assisted by an iridectomy downwards and inwards.

TUMOURS of the cornea are excessively rare as primary growths; dermoid cysts, epithelioma, and sarcoma originating in the limbus of the conjunctiva affect the cornea by extension. Cysts lined by laminated epithelium may occasionally be found in the substance of the cornea.

INJURIES OF THE CORNEA.—**Foreign bodies**, as small particles of iron, dust, scales like insects' wings, &c., are frequently found adhering to or embedded in the cornea. The *symptoms* are very acute, and consist

of profuse lachrymation, extreme pain on movement of the lids over the eye, and photophobia. The *signs* are generally very slight compared to the pain and discomfort experienced by the patient, and usually consist of slight ciliary congestion. A foreign body can be diagnosed from an abrasion or staining, by its being raised above the cornea, and this can be best observed by focal illumination aided by a magnifying lens. If it has been present for some days the cornea around it becomes steamy and nebulous, and, in the case of a piece of steel or iron, the immediately surrounding cornea is stained by rust. The usual *course* in such cases, if the foreign body is not removed, is for it to set up ulceration of the cornea, which may lead to its dislodgment.

FIG. 29.—SPUD

The *treatment* is to remove the foreign body, and this is best done under cocaine. The patient should be sitting down and facing a good light; the operator, standing behind and supporting the head, takes a needle or spud (fig. 29) in his right hand, and steadies the eye by raising the upper lid with the index finger of his left hand, and pressing the tip of the ring finger of the same hand against the sclerotic; the lower lid is depressed by the little finger of the right hand, and the foreign body removed by gently raising or picking it out with the needle or spud. A drop of oil should be placed in the eye, and a bandage applied. If the foreign body be very deeply implanted, great care must be taken not to perforate the cornea with the needle, and in such cases a general anæsthetic may be advisable. The ring of staining left by a particle of metal should, if possible, be removed

by the spud. Iron or steel may be extracted by a magnet.

Burns and scalds of the cornea are almost invariably associated with the same condition of the conjunctiva, and should be treated in the same way (p. 68).

Wounds of the cornea are divided into non-perforating and perforating.

Non-perforating wounds are generally abrasions, and the most common cause is a scratch from the fingernail of an infant. They are accompanied by great pain, must be treated like an ulcer, the eye being firmly bandaged afterwards.

Perforating wounds (fig. 31, *a*), other than operation wounds, are generally complicated by prolapse of the iris, injury to the lens and other parts of the eye. The signs are diminution of intra-ocular tension, shallow anterior chamber, and contracted or irregular pupil.

Treatment of a small uncomplicated wound is by a pad and bandage and atropine or eserine drops, according to its position ; if the wound is an extensive one it may be stitched together. In a complicated case the treatment must vary according to the nature of the complication.

CHAPTER VI

DISEASES OF THE SCLEROTIC

Anatomy.—The sclerotic, comprising the posterior five-sixths of the protective coat of the eyeball, varies from 1·25 mm. in thickness near the optic nerve entrance to ·5 mm. at the distance of 5 mm. from the corneal margin. It is composed of very firm, tough fibrous connective tissue, and differs from the cornea (into which it passes imperceptibly) in not being transparent. Behind, it is continuous with the sheath of the optic nerve. The sclerotic contains blood-vessels, and these are most abundant near the cornea, where a marked network exists for the supply of nutriment to the cornea; this area in inflammation forms part of the *circumcorneal zone*. There are no marked lymphatic vessels, though numerous lymphatic spaces exist in the sclerotic, which has on its inner surface a lymphatic tract separating it from the choroid, and on its outer surface another lymph space between it and the capsule of Tenon. The most important part of the sclerotic (fig. 64) is at its junction with the cornea, where are situated the *canal of Schlemm*, the *spaces of Fontana, perforating vessels, ligamentum pectinatum iridis*, and the *tendon* of the *ciliary muscle*. The canal of Schlemm, situated in the sclerotic, forms part of the main filtration system of the eyeball, by which the aqueous humour passes out into the anterior ciliary veins. Posteriorly, 2·5 mm. internal to the antero-posterior

axis of the eyeball, is the point of perforation of the *optic nerve*, and at this spot the sclerotic is reduced to a few interlacing bundles, to which the name of *lamina cribrosa* has been given. The weakest parts of the sclerotic are at the entrance of the optic nerve, as shown pathologically by cupping, and on either side of the insertions of the extrinsic ocular muscles, where rupture of the eyeball most frequently occurs.

Congenital affections of the sclerotic are mainly anomalies of pigmentation; some cases have been recorded in which the sclerotic is of a bluish plum colour, and a few of these were associated with melanotic sarcoma of the uveal tract.

SCLERITIS, or inflammation of the sclerotic, may be divided into superficial and deep. *Superficial scleritis*, better known as *episcleritis*, affects the structures superficial to the sclerotic—namely, the subconjunctival tissue and the anterior portions of the capsule of Tenon—and, as a rule, exhibits no tendency to spread to the deeper structures. *Deep scleritis* involves the sclerotic itself primarily, and secondarily the subjacent uveal tract and other parts. Both forms are especially prevalent in rheumatic patients, are prolonged in their course, apt to recur, and are characterised by a violet-shaded vascularity, due to engorgement of the episcleral vessels. The two divisions tend to merge into each other, but episcleritis is more patchy in its vascularity, recurs more frequently, is less painful, and does not affect vision as much as deep scleritis.

Episcleritis is extremely troublesome owing to its chronic course, and its tendency to recurrences and relapses, though it is seldom dangerous to sight.

The *symptoms* are not usually well marked, beyond a feeling of general discomfort in the eye, though there may be lachrymation and photophobia. The disease is characterised by the presence of vascular inflammatory patches of a pinkish or violet colour, generally found

between the cornea and the insertions of the recti muscles. The conjunctiva is movable over the blood-vessels of the patches, which may be slightly raised or nodular, and sometimes much resemble phlyctenules. They are usually situated on the temporal side, but the upper quadrant is not an uncommon seat, and here, under the upper lid, they may exist for some time without being discovered, owing to the little discomfort they produce.

Whilst one patch is disappearing, another will often be developing. They have no tendency to suppuration or ulceration, but eventually become absorbed. Vision is unaffected as a rule.

Complications and sequelæ.—If the patch of episcleritis be very close to the cornea, this membrane may become involved; the episcleral tissue at the site of a patch may remain permanently of a slaty-blue colour, and somewhat flattened after the disappearance of all inflammation.

The diseases resembling episcleritis are scleritis, phlyctenular conjunctivitis, and gummata of the sclerotic.

Causation.—Episcleritis is rarely found except in adults, and occurs more often in the female sex, especially in those with menstrual trouble. The rheumatic, the gouty, and the dyspeptic are its chief victims.

Anæmia and syphilis are predisposing causes.

Treatment.—In those cases in which there is but little discomfort the main treatment is constitutional and hygienic.

In the acute stage it is best to order atropine drops (F. 1) to keep the pupillary and ciliary muscles at rest. If there be pain, leeches and blisters may be applied to the temple. Warm fomentations and salicylate lotion (F. 29) are soothing, and subconjunctival injections of perchloride of mercury (1 in 5,000) have been recommended. Massage of the eye is often very effectual, and should be carried out by first instilling a drop of cocaine,

and then five minutes afterwards introducing a little simple ointment into the eye. The lids should be lightly rubbed over the inflamed patch by circular movements with the finger. If the complaint be very chronic, local stimulation by means of calomel and yellow oxide of mercury ointment (F. 40) may be induced, or the patches may be scraped with a sharp spoon. Tinted glasses may be worn for protection of the eyes.

Scleritis (*deep scleritis*) is generally acute and almost always associated with rheumatism or gout, and for this reason has been called *rheumatic ophthalmia.*

The *symptoms* are pain and tenderness over the ciliary region; the pain, often very intense (the globe feeling tight and ready to burst), is dull, heavy, and aching in character, and is transmitted along the supra-orbital and nasal branches of the ophthalmic nerve, being most severe at night or in the early morning. There is great tenderness on pressure, often with increase of tension which may end in glaucoma. The disease commences with extreme vascularity of the conjunctival and episcleral vessels, which may be in patches as in episcleritis, but the congestion soon tends to become general and of a dusky reddish-blue colour; there is sometimes œdema of the conjunctiva. There may be also lachrymation, photophobia, a mucous or mucopurulent discharge, and much diminution of the acuteness of vision, even at an early stage, owing as a rule to the opacities in the vitreous.

Complications and sequelæ.—In rheumatic patients the affection is probably never confined to the sclera; the cornea is frequently involved by spreading of the inflammation to its fibrous tissue, producing nebulæ and sometimes ulcers. Iritis, cyclitis, and uveitis often supervene, and opacities in the vitreous are common. In severe cases thinning and staphylomatous bulgings of the sclerotic occur, especially anteriorly.

The *prognosis* is unfavourable in most cases as regards

ultimate vision, owing to the implication of the uveal tract; but it is extraordinary how cases tend to clear up, and how vision returns, even when reduced to the counting of fingers. Patients should be warned of the likelihood of recurrence, and of the necessity for avoiding such predisposing causes as exposure to cold and climatic influence, especially in the spring.

The *treatment*, unless contra-indicated, should be vigorous from the first. A purgative such as calomel should be given at once, and two to six leeches applied to the temples to relieve the pain and congestion. When the bowels have acted, a mixture of colchicum aconite and quinine, salicylate of soda, or mercury with chalk, may be administered.

The pupil must, if possible, be kept dilated with atropine and the tension carefully watched; fomentations as belladonna give great relief, and the eye should be bandaged.

When the inflammatory symptoms have abated, tinted glasses should be worn, and great attention paid to dietetic and hygienic conditions. As the disease is liable to relapse, a change of air is essential, green fields being preferable to the glare of the seaside. The eyes must be rested as much as possible, and bright lights avoided.

BULGINGS OF THE SCLEROTIC are met with in two forms: (1) As localised bulgings (*staphylomata*); (2) a general expansion.

Localised scleral staphylomata are divided into anterior and posterior; and with the anterior are included those which occur at the equator, known as equatorial.

Anterior scleral staphylomata are found in the portion of the sclerotic adjoining the cornea, and appear as bluish or slate-coloured shining prominences, over which some blood-vessels can be seen to ramify. When multiple, they tend to become confluent, and may form an annular staphyloma surrounding the cornea.

If a staphyloma occurs suddenly during an attack of

cyclitis it may have been preceded by severe neuralgic pain, with much tenderness of the whole globe. It may be accompanied by deep vascular congestion, but generally there are no marked symptoms.

The tension of the eye is raised or normal, and sometimes inflammation of the cornea, iris, and the rest of the uveal tract is present.

After lasting some time, arrest of growth may take place, but rupture occasionally occurs and leads to shrinking of the globe.

Equatorial bulgings, from their situation, are sometimes difficult to see.

Causation.—Anterior staphylomata are generally secondary to inflammation of the uveal tract, with complications, but may follow scleritis.

The *prognosis* is unfavourable owing to the tendency of the bulging to increase. In the early stages the *treatment* should be directed towards arresting the growth of the staphyloma by constitutional means, as mercury; by the local application of atropine or eserine; by leeches to the temporal region, and by firm pressure with a bandage. If the bulging still increases, repeated paracenteses of the anterior chamber, combined with firm bandaging, are to be recommended, or an iridectomy may be performed.

Failing this, the staphyloma should be incised or removed by an elliptical incision and the edges of the wound stitched together. If the deformity is great, evisceration or excision of the eyeball is called for.

Posterior bulgings are only to be seen in the living eye by means of the ophthalmoscope, since they occur in the vicinity of the optic nerve, and are almost always associated with myopia. By the ophthalmoscope, posterior staphylomata appear as white crescentic depressed patches with the concavity embracing the optic disc (fig. 41).

General expansion of the sclerotic is found in the

young, and is, as a rule, associated with staphyloma of the cornea. One form, in which the cornea participates in the enlargement, is known as buphthalmos (p. 273).

OPERATIONS.—By **sclerotomy** is understood the division of the sclerotic, generally above, in such a way that the section lies as far back in the anterior chamber as possible, a bridge of sclerotic being left in the middle. It is performed for the relief of glaucomatous symptoms, but I have found it of little use except in cases where an iridectomy has failed to keep down the tension.

Instruments.—Speculum (fig. 23), fixation forceps (fig. 19), a Graefe's knife (fig. 57), and tortoiseshell spatula (fig. 30) or curette (fig. 25).

The preliminary steps are the same as for iridectomy (p. 117), and the pupil if possible should be contracted under eserine.

FIG. 30.—TORTOISE-SHELL SPATULA

Operation.—The operator, standing behind the patient's head, fixes the conjunctiva with the forceps about 1 mm. below the cornea, and depresses the eye. He then makes a puncture with the knife through the conjunctiva and sclerotic on the temporal side, about 1·5 mm. from the corneal margin, and at the junction of the upper sixth with the lower five-sixths of the cornea. He next passes the knife, with great care, across the anterior chamber, and makes the counter-puncture at a point on the nasal side of the sclerotic corresponding to the original puncture. The knife is now made to cut its way upwards through the sclerotic, by to-and-fro movements, until a small bridge of sclerotic, about 2 mm. broad, is left undivided, when the knife is slowly withdrawn. In many cases

there is prolapse of the iris into the operation wound, which must be replaced with a spatula or curette, and eserine (F. 13) used to keep the pupil contracted. The eye must be bandaged for at least 24 hours.

Scleral punctures by a keratome or Graefe's knife may be done in any part of the sclerotic, generally about the equator of the eye, and in an antero-posterior direction. They are performed for the relief of glaucomatous symptoms; as a preliminary step to an iridectomy for glaucoma, when the anterior chamber is very shallow; and also to let out the fluid in detachment of the retina.

INJURIES OF THE SCLEROTIC.—**Burns and scalds** of the conjunctiva may also implicate the sclerotic, especially if neglected. The ulcer produced is very chronic, and gives rise to a slough, which takes a long time to separate, owing to the want of vascularity of the sclerotic. In the more severe cases perforation may take place, followed by loss of vitreous, and even panophthalmitis.

The *treatment* is to promote vascularity by fomentations, and to stimulate the ulcer by iodoform, or by the actual cautery.

Rupture of the sclerotic results from blows by the fist, by some blunt instrument, or by the patient striking his eye against some obstacle. They are among the most severe injuries to the eye; the sight is frequently lost, and the eye in many cases has to be excised. The rupture occurs, as a rule, between the edge of the cornea and the insertion of the recti muscles. The symptoms and treatment are the same as in perforating wounds of the sclerotic.

Perforating wounds of the sclerotic are produced by sharp instruments, as a knife, hook, scissors; or by blunt instruments if sufficient force be employed.

The *symptoms* are diminution of intra-ocular tension,

and, as a rule, a certain loss of vision. In many cases the seat of injury (fig. 31, *b*) can be seen, with vitreous fluid, blood and uveal pigment exuding from the wound. There is generally hæmorrhage into the vitreous and aqueous chambers, which prevents a clear view of the fundus being obtained. In some cases the lens may escape through the wound, and frequently serious injury, as detachment of the retina or rupture of the choroid, ensues.

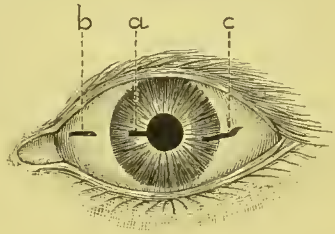


Fig. 31.—Perforating Wounds
a, corneal ; *b*, scleral ; *c*, sclero-corneal

Treatment.—In all cases the history of the injury must be carefully investigated, and the instrument examined as to the likelihood of a foreign body being in the eye; ophthalmoscopic examination as far as possible should be made, though the want of transparency in the media as a rule renders this extremely difficult.

The injury is much complicated by the presence of a foreign body, which may be removed by a fine pair of forceps, or, if of iron or steel, by an electro-magnet.

If the scleral wound is small, the conjunctiva should be stitched over it; but if it be large, the sclerotic itself should be sutured. This is best done by means of a piece of fine silk with a needle at either end; each needle is passed through the wound and pierces the sclerotic at opposite sides of the wound from within outwards. The patient must afterwards be kept at rest, with both eyes bandaged, and a cold compress or Leiter's tube (fig. 105) applied to the injured eye. The danger in all these cases is that the instrument producing the injury is not clean in which case sepsis may ensue.

Sclero-corneal wounds (fig. 31, *c*) are more dangerous, as a rule, than corneal or scleral, from

the implication of the ciliary body, and therefore are more likely to set up sympathetic ophthalmitis. Till a few years ago the rule was to excise all eyes with a sclero-corneal wound, but now, owing to the care exercised in rendering wounds aseptic, the danger of these injuries is greatly lessened. They should be treated, unless the complications are severe, as other wounds of the sclera, but it is very important that the patient should be seen from time to time. He must be warned of the danger likely to ensue if the injured eye becomes inflamed or tender, or if the sight of the other eye deteriorates.

CHAPTER VII

DISEASES OF THE IRIS

Anatomy.—The *uveal tract* or vascular coat of the eye may be divided into three portions from before backwards, the iris, the ciliary body and the choroid. It must be remembered that as histologically and embryologically they are identical, so pathologically disease in one part of the tract is frequently found in the others.

The iris is the coloured portion observed on looking at the eye, and acts as a diaphragm, the central aperture (seen black by the naked eye) being known as the pupil. On examination by focal illumination the iris may be seen to consist of a slightly elevated pupillary portion, corresponding to the situation of the sphincter pupillæ muscle, and a ciliary portion arranged in radiating folds, between which are slight depressions, known as the crypts. These details are best observed by means of a strong platyscopic lens.

Histologically, the iris may be divided into two parts, the mesoblastic or anterior, and the epiblastic or posterior. The anterior or thicker portion, lined by endothelium continuous with that of the membrane of Descemet, consists chiefly of a reticular form of connective tissue made up of spindle-shaped cells and elastic fibres. Behind this are the blood-vessels, held together by a similar connective tissue containing pigmented cells, nerve fibres and the musculature of the iris.

Surrounding the pupil is the sphincter iridis, composed of unstriped muscular fibres.

The pigment cells in the anterior parts of the iris account for the variation in its colour; in a brown iris there is a large amount of pigment, whilst in blue irides this pigment is scanty or absent. All infants at birth have blue irides.

The posterior or epiblastic division of the iris consists of two layers of pigmented epithelium (except in albinos) continuous with the pigment layer of the retina. The blood-vessels of the iris are derived from the long ciliary branches of the posterior ciliary and from the perforating branches of the anterior ciliary.

The nerve supply is from the plexus in the ciliary body by the long and short ciliary nerves, from the third, the nasal branch of the ophthalmic, and the sympathetic.

The physiological functions are described at p. 125. The great sensibility of the iris to pain is due to its extensive nerve supply from the nasal, and its liability to congestion to its free blood supply.

CONGENITAL DEFECTS.—**Irideremia** (*ἐρημία*, want), aniridia, or absence of the iris, is a very rare condition, and is generally accompanied by dimness of vision, nystagmus, and congenital opacities in the lens and cornea. The affection may be complete or partial, and, as a rule, occurs in both eyes.

Coloboma (*κολόβωμα*, mutilation) is a cleft in the iris looking like a perfectly made iridectomy; it is almost always situated downwards, or downwards and inwards, and is due to arrest during fœtal life of the closure of the choroidal fissure. The sphincter pupillæ lines the pupillary edge of the cleft. It may be combined with coloboma of the ciliary body, choroid, or more rarely of the lens.

Persistent pupillary membrane and **capsulo-pupillary membrane** are the remains of a vascular

structure which stretches across the pupil during the greater part of fœtal life, and normally should disappear at the seventh month. The remains are greyish, and spring from the anterior surface of the iris at a little distance from its pupillary edge; they may either stretch from one side of the iris to the other (*pupillary membrane*), or from the iris to the capsule of the lens (*capsulo-pupillary*). The bands are very elastic, and allow the pupil to dilate and contract without producing marked irregularity, as is the case with posterior synechiæ, from which they are also distinguished by the fact that they do not start from the pupillary margin.

Heterophthalmos (*heterochromia iridis*) is the term applied to the condition in which one iris may differ in colour from the other, or may itself be of two different colours.

Corectopia (*κόρη*, pupil; *ἐκ*, out of; *τόπος*, place) is a malposition of the pupil, which may be as far from the centre of the iris as the corneal margin.

Polycoria (*πολὺς*, many; *κόρη*, pupil) is the condition in which there are orifices in the iris tissue forming supernumerary pupils. These apertures are separated from the normal pupil by a bridge of varying thickness.

IRITIS, or inflammation of the iris, varies greatly in its severity; some cases are very acute in onset and in course, others scarcely show any general ocular signs of inflammation. In its incipient stages it is characterised by supra-orbital pain and aching of the eye, dimness of vision, lachrymation, circumcorneal zone, and contraction of the pupil. The following signs and symptoms are found more or less marked in every case of iritis, and are here arranged with reference to the state of the iris itself, the condition of the pupil and anterior chamber, and the adjacent parts of the eye. *The iris* is dull instead of being finely polished, its markings are ill-defined, the colour becomes altered, and the general texture appears

thickened. All these alterations are due to congestion of the iris with exudation of cells and lymph into its substance, and to changes in the anterior chamber. The exudation fills up the crypts and reaches the anterior surface, leading to loss of polish, disappearance of the beautiful markings, and in consequence the iris appears swollen and thickened, especially at its pupillary margin.

Change of colour is generally very manifest—a blue iris appearing green, and a brown iris muddy. Occasionally in severe cases, especially those which have lasted a long time, tortuous blood-vessels can be seen on the surface of the iris. *The pupil* is contracted, irregular, and sluggish in its movements. The irregularity is due to surface exudation, which in this case appears behind and gums the posterior surface of the pupillary border of the iris to the anterior capsule of the lens (*posterior synechia*). The irregularities and adhesions are well seen after the instillation of atropine (fig. 32).

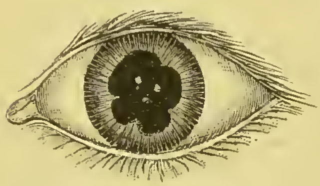


FIG. 32.—PUPIL DILATED BY ATROPINE SHOWING POSTERIOR SYNECHIA AND UVEAL PIGMENT PATCHES ON ANTERIOR CAPSULE

The contents of the *anterior chamber* are turbid; its depth may be increased or normal.

On the back of the *cornea* there frequently occur minute dust-like deposits; and on the *anterior capsule* of the ens are small patches of uveal pigment left from posterior synechiæ.

In the sclerotic immediately surrounding the cornea there is a well-marked pink *circumcorneal zone*, about one-eighth of an inch wide, but not always noticeable owing to general congestion of the eyeball.

The tension of the eyeball is either increased or normal.

The symptoms common to all forms of iritis are pain, lachrymation, photophobia, and diminution of acuteness

of vision. The *pain* is neuralgic in character, shooting and throbbing; it is worse at night or in the early morning, and is referred along the ophthalmic division of the fifth nerve, especially its supra-orbital branch. Accompanying the pain there is tenderness over the supra-orbital notch.

The *lachrymation* and *photophobia* vary considerably in degree.

Acuteness of vision may be normal in uncomplicated cases, but is usually slightly diminished from turbidity of the aqueous humour, and deposits on the anterior capsule of the lens, and on Descemet's membrane.

Though, without other signs of constitutional disease, one cannot say definitely that a case is syphilitic iritis, rheumatic iritis, &c., yet there are certain peculiarities confined to special varieties, and a slight account of the distinctive features is given below.

Syphilitic iritis is an early or late manifestation of the secondary stage of acquired syphilis, but sometimes occurs in the hereditary form. In most cases it is acute, attacking both eyes, as a rule one before the other, at intervals, and seldom relapses. It is accompanied by the exudation of lymph in the neighbourhood of the pupil, and this lymph may either assume the form of one or more distinct yellowish nodules, or may produce a general thickening of the pupillary ring. The pain is not very great. Some cases, without great effusion of lymph and associated with well-marked punctate keratitis, are found both in acquired and hereditary syphilis as a very late manifestation of the disease.[1]

Rheumatic iritis is extremely prone to relapse and frequently only attacks one eye; the effusion of lymph is not very marked or nodular. Relapses often occur at

[1] 'On the Iritis of the Later Stages of Syphilis,' by W. H. Brailey, *Trans. Ophth. Soc.* vol. xv. p. 93.

the same time of year as the original attack. The pain and accompanying neuralgia are generally severe. A form of rheumatic iritis, sometimes called **gonorrhœal iritis**, is found in patients with prolonged gleet and gonorrhœal rheumatism.

Suppurative iritis is usually traumatic, associated with hypopyon, and is, as a rule, a part of a general panophthalmitis.

Gouty iritis is an insidious form met with in gouty subjects, and may be attended by a spongy exudation in the anterior chamber.

Fœtal iritis occurs sometimes during intra-uterine life, and is accompanied by uveal pigmentation on the anterior capsule of the lens, presenting a mossy appearance, and is associated with opaque milk-like spots in the lens.

Quiet iritis [1] is the name given to those cases unaccompanied by pain, photophobia, and ciliary congestion, in which posterior synechiæ and the other results of iritis take place insidiously. This form is commonly associated with congenital syphilis or a rheumatic or gouty tendency.

Course and progress of iritis.—The disease mostly attacks one eye at a time, but occasionally implicates both at once. An attack of acute iritis may last only a few days or continue for a month or longer, and if neglected it may end in loss of sight.

Causation.—The exciting causes of iritis are exposure to changes of temperature, especially cold; over-work, inducing fatigue of the iris; bright light; and a depressed state of general health. Iritis is a complication of certain constitutional diseases and diatheses, such as rheumatism, syphilis, gout, and tubercle, and it may also have a

[1] 'Quiet Iritis,' by J. Hutchinson, jun., *Trans. Ophth. Soc.* vol. viii. p. 117.

traumatic origin or be secondary to inflammation of the cornea, sclerotic, and the other parts of the uveal tract.

Complications and sequelæ.—The most common sequela is the presence of one or more *posterior synechiæ*, and when the whole pupillary border is adherent to the lens capsule by synechiæ, the term *annular synechia* is applied. As a consequence of the latter condition the fluids behind the iris, being unable to reach the anterior chamber, cause the non-adherent parts of the iris to bulge forward (*Iris bombé*). The periphery of the iris may become adherent to the cornea at the iridic angle, producing *secondary glaucoma.* Organised exudation of lymph may lead to occlusion of the pupil. The colour and appearance of the iris may remain permanently altered, and in some cases *patches of black pigment* occur on its anterior surface, having migrated from the uveal pigment at the pupillary margin. *Atrophy* of the iris follows repeated attacks of iritis, and can be recognised by grey patches and sometimes holes, through which the red reflex can be seen by the ophthalmoscope. Deposits are left on the anterior capsule of the lens and on Descemet's membrane, and *cyclitis* and *choroiditis* may also result.

Pathology.—There is an exudation of round cells and lymph into the tissue proper of the iris, producing thickening and swelling of the stroma, and thus obscuring the delicate markings on its anterior surface. This exudation finds its way into the anterior chamber, and leads to turbidity of the aqueous humour, and to deposits upon Descemet's membrane, and the anterior capsule of the lens. At the posterior aspect of the iris the exudation unites the pupillary border to the anterior capsule of the lens, producing posterior synechiæ. If the exudation is extreme it is seen as plastic lymph. The engorgement of the blood-vessels associated with the inflammatory

changes produces contraction of the pupil (*congestion miosis*).

Diagnosis.—Incipient iritis may be mistaken for conjunctivitis, but the pink colour of the congested episcleral tissue, and the sluggishness of the pupillary movements, together with the alterations in colour and appearance of the iris, should suggest iritis. All doubts may be set at rest by observing if the pupil dilates properly to atropine or homatropine.

Prognosis.—This so far as concerns duration depends on the severity, cause, treatment, and presence of complications. If the adhesions be but few, and soon broken down, the attack will probably be short. Syphilitic cases clear up as a rule very well, except when the deeper parts of the eye are also involved. Rheumatic and gouty iritis have a slower course, and are liable to recur. In these latter cases, if synechiæ still remain after an attack, there is greater probability of a recurrence. Vision is often completely restored, even when it has been greatly reduced owing to the attack.

Local treatment must be directed: (1) *To induce mydriasis and keep the iris at rest*; (2) *To relieve pain and congestion*; (3) *To avoid irritation of the eyes.*

1. The most essential point is the production of mydriasis. In the normal or moderately dilated pupil the pupillary border is in contact with the anterior capsule of the lens, but in the widely dilated pupil of atropine the posterior iridic surface leaves the capsule of the lens owing to the convex shape of the latter, and therefore adhesions do not so readily take place. Atropine mydriasis thus prevents the formation of synechiæ, and breaks them down if not too firmly adherent, and at the same time gives rest to an inflamed structure, and is most effectively induced by drops (F. 1) or ointment (F. 2). The atropine is to be applied every two hours at first, until dilatation has been effected, and afterwards, three or four times a day. If the pupil does not dilate

completely, a 4 p.c. solution of cocaine should be dropped into the eye, immediately after the atropine, as the combination has a more rapid and powerful effect. In some patients atropine produces irritation, shown by an eczematous condition of the lids, or even poisoning symptoms; in such cases daturine (F. 7) or scopolamine (F. 8) may be substituted.

In cases where high tension is present, leeches should be first tried and, failing this treatment, eserine may be used; if the case can be carefully watched, atropine, by breaking down the adhesions, often relieves the symptoms.

2. To relieve pain and congestion fomentations of belladonna (F. 4), poppy (F. 39), or boroglyceride (F. 38) must be used; leeches (one or two at a time) to the temple give most relief to pain, whilst in severe cases subcutaneous injections of morphia may be necessary. Atropine, used chiefly to produce mydriasis, has also a sedative effect. Dry as well as moist heat may be employed. Cold applications ought not to be used except in traumatic cases. In every case the eye must be bandaged.

3. Irritation of the eyes may be prevented by refraining from near work and reading with the sound as well as with the affected eye, and by avoiding bright light, not necessarily living in a darkened room, but wearing shades or tinted glasses.

Operative measures.—In iritis with persistent high tension, paracentesis of the anterior chamber may be performed to reduce the tension. In recurrent iritis when posterior synechiæ are present, iridectomy may be performed after two or three attacks. This operation has undoubtedly prevented recurrence, but should never be performed during an attack.

Constitutional treatment must be modified according to the form of the disease, but in most cases, unless contra-indicated, small doses of mercury should be administered.

In the acute stage, patients should be kept in bed, and

when allowed to get up, must live in an even temperature and draughts be carefully avoided.

TUMOURS OF THE IRIS are divided into inflammatory and new growths.

Inflammatory tumours. Infective granulomata.—The *syphilitic* are small rounded elevations about the size of a millet seed occurring near the pupillary border; occasionally there may be a single tumour, which may grow and fill the anterior chamber.

Tubercular deposits are yellowish in colour, associated with plastic iritis; they generally occur in one eye only, and end in its destruction. Pathologically, they consist of masses of round cells, amongst which are giant cells and tubercle bacilli.

New growths.—The *Innocent* are generally *cysts*. Two varieties are met with, one transparent, containing serum, and the other grey in colour, having epithelial contents (*pearl cysts*). Besides these, *cysticercus* is met with, growing from the iris into the anterior chamber. If the cysts tend to increase in size they must be removed, with the portion of the iris from which they grow, by iridectomy. A *Melanoma* is occasionally to be found, and may be mistaken for sarcoma.

Malignant.—*Sarcoma* is of rare occurrence; it springs from the anterior surface of the iris, and is generally pigmented. The treatment consists in the removal of the growth, if small, with a portion of the iris; but if large, excision of the eyeball must be resorted to.

OPERATIONS.—**Iridectomy** or excision of a portion of the iris is performed (1) to improve the sight in cases of corneal opacity, lamellar cataract, and anterior polar cataract; (2) as a remedial measure in glaucoma, recurrent iritis, complete posterior synechia, tumours of the iris, and injury; (3) as a part of the operation of cataract extraction, either at the time of the extraction or as a preliminary procedure to the same.

Iridectomy by a corneal incision.—Instruments required are speculum (fig. 23), fixation forceps (fig. 19), a knife (keratome) (fig. 33), iris forceps (fig. 34), iridectomy scissors (fig. 35), and a curette (fig. 25) or tortoiseshell spatula (fig. 30). The instruments, with the exception of the knife, must be boiled, and then placed in a dish containing boracic or carbolic lotion. The knife should be dipped into absolute alcohol just before being used.

Anæsthetics.—As the operation is a painful one, a general anæsthetic

FIG. 33.—KERATOME

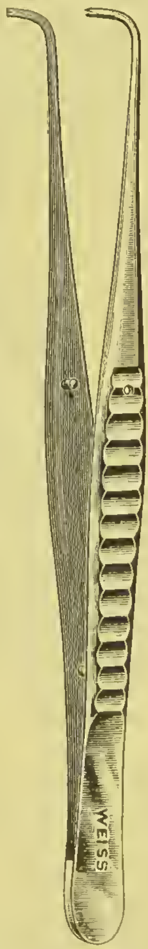


FIG. 34.—IRIS FORCEPS

should, as a rule, be administered, preferably chloroform, as ether causes much congestion of the iris. If cocaine be used, a 4 p.c. solution should be applied to the con-

junctiva three times, at intervals of five minutes, beginning ten minutes before the operation, and again instilled after the corneal section, so as to increase its effect by direct contact with the iris.

Position of patient.—The patient is lying down on his back on a table, with his head supported on a pillow, in a good light.

Preparation of eye.—The conjunctival sac should be washed out with boracic acid solution (F. 24) or distilled water, and the speculum introduced.

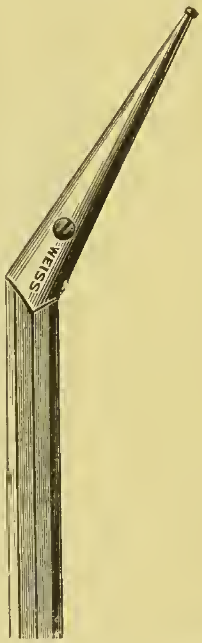


FIG. 35.—IRIDECTOMY SCISSORS

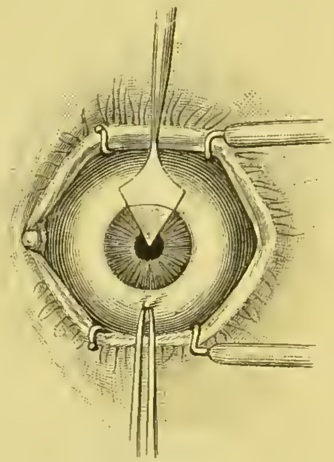


FIG. 36.—IRIDECTOMY, SHOWING FIXATION OF EYE AND CORNEAL SECTION BY KERATOME

Operation.—The operator, standing behind the patient's head, seizes the conjunctiva firmly and gently about 1 mm. from the corneal edge, opposite the site of the proposed corneal incision, with a pair of fixation forceps held in the left hand. With the keratome in the right hand, he passes its point through the periphery of the cornea (fig. 36) at a spot corresponding to the middle of

the proposed coloboma. Care must be taken to push the keratome through the cornea into the anterior chamber, and not, as may easily be done, between the layers of the cornea. The handle of the knife is lowered till the point nearly touches the posterior surface of the cornea, in order to avoid wounding the lens should the aqueous escape. As soon as the corneal wound is large enough, the keratome is slowly withdrawn, this being followed by escape of the aqueous. The fixation forceps, still holding the conjunctiva, are then given to an assistant to keep the eye steady. The operator passes the iris forceps through the corneal wound with their points closed and directed towards the posterior surface of the cornea; the blades are now opened and the pupillary border of the iris seized between them. The iris so held is slowly and with care drawn out, and the portion withdrawn cut off with the iridectomy scissors (fig. 37).

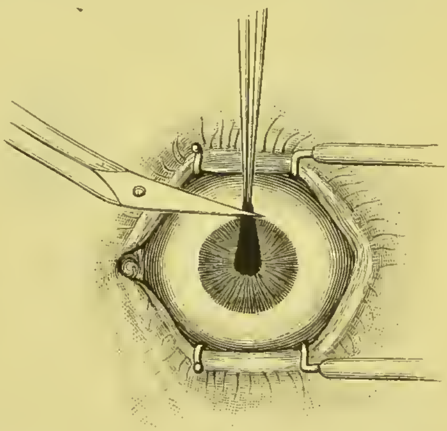


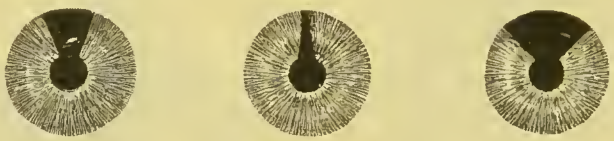
Fig. 37.—Iridectomy, showing Section of Iris by Scissors

This may be done either parallel to the wound, producing a coloboma with a broad periphery (fig. 38, A), or at right angles to the wound across the cornea, the coloboma then having a narrow periphery (fig. 38, B).

The edges of the cut iris are carefully returned with a spatula or curette, and the operator must see that the pupillary margin on both sides is in position. The eye is now washed out again with the solution mentioned above, and bandaged up. In a simple case of iridectomy, the bandages may be discontinued in twenty-four hours

if the anterior chamber is formed and the eye not irritable. In most cases, however, the bandages should be retained for at least two days. Atropine drops should be applied on the second day, to make sure that the edges of the newly formed pupil have not contracted adhesions. It is a good plan for the patient to wear tinted glasses for a week after the operation, and to avoid excessive light. If there be great pain after the operation, it is best to apply leeches to the temple or behind the ear.

Complications during the operation.—(1) Hæmorrhage from the iris, which seldom gives rise to serious trouble except in old people, when the blood may become organised. If the anterior chamber be filled with blood, the introduction of a curette will usually set free the



A B C

FIG. 38.—ARTIFICIAL PUPILS

greater part, the rest becoming absorbed afterwards. (2) The iris may not be removed up to the pupillary border, which is then left undivided. (3) The edges of the cut iris may be difficult to replace. (4) The anterior capsule of the lens may be bruised or lacerated, and thus give rise afterwards to cataract.

After complications may be: Iritis, with anterior or posterior synechiæ; Failure of healing of the wound; Recurrent hæmorrhage; Prolapse of iris; Astigmatism.

Modifications.—The operator may make the corneal section with a Graefe's knife instead of with a keratome. In such a case he would introduce the point of the knife through the periphery of the cornea, at a spot corre-

sponding to one edge of the coloboma he intends to produce. The knife, being then passed across the anterior chamber, transfixes the periphery of the cornea at a point corresponding to the other edge of the desired coloboma, and is made to cut its way out. The succeeding steps are the same as in the preceding operation. If the object be to remove a small piece of iris, as in an optical iridectomy, the hook (fig. 39) may be used instead of the forceps to withdraw the iris.

Fig. 39.—Iris Hook

Iridectomy with scleral incision.—In iridectomy for glaucoma, the patient should if possible be under a general anæsthetic, as the operation is accompanied by a great deal of pain, mainly due to the non-absorption of cocaine owing to the inflammation or high tension.

The operation may be done with a keratome, but most surgeons prefer a Graefe's knife. The preliminary steps are the same as in the operation above described (p. 117). The operator introduces a Graefe's knife through the sclerotic about 1 mm. from the apparent corneal margin, and about the junction of the upper one-sixth with the lower five-sixths of the cornea. The knife is then passed across the anterior chamber with great care, so as not to wound the iris or lens capsule (easily done owing to the shallow anterior chamber), and makes a counter-puncture in the sclerotic at a corresponding point on the opposite side. The knife is then made to cut its way out by to-and-fro movements through the sclerotic above, producing an arc in this structure corresponding to the curve in the cornea. The iris is seized by a pair of iridectomy forceps at one edge of the section, and carefully drawn out. It is then cut with the scissors and torn across to the opposite edge of the wound, where it is again severed.

The edges of the iris are carefully replaced, and the eye washed out and bandaged as above.

Situation of the coloboma.—If the operation is done to improve sight (*optical iridectomy*), the best position is downwards and inwards, so as to be in a line with the visual axis; but in cases of corneal opacity the site chosen must correspond with the most transparent part of the cornea.

For glaucoma or for cataract extraction, the operation is performed upwards, to prevent the admittance of too much light, and to hide as much as possible the disfigurement of the coloboma. If the operation is done on both eyes, the artificial pupils should, if possible, be symmetrical—that is, the colobomata should both be temporal, nasal, superior, or inferior.

Size of the coloboma.—If the object be to make an artificial pupil, the coloboma should be as small as practicable; but if to relieve tension, the portion of iris removed must be as large as possible, reaching to the periphery. In each case the size of the coloboma depends on the extent of the corneal or scleral incision.

Iridotomy is performed in cases in which the lens is absent or out of position and the pupil occluded by lymph, or the iris drawn up to a scar in the cornea.

Operation.—The eye being under cocaine, a very thin Graefe's knife is used with its cutting edge downwards, to puncture the cornea near the periphery and is passed into the anterior chamber till its point reaches the inner limit of the desired pupil. The handle of the knife is then raised, and the blade cuts through the iris as far as is desired. The iris incision then opens up and forms a pupil. This operation may also be done with a pair of iridectomy scissors.

INJURIES OF THE IRIS may be divided into (1) those resulting from concussion without perforation, and (2) those caused by a perforating wound of the eyeball.

1. **Results of concussion.**—*Dilatation of the pupil* (mydriasis) is the most common, and, as a rule, is permanent. The only treatment is eserine to produce contraction of the pupil.

Irido-dialysis (ἶρις, iris; διάλυσις, separation) (fig. 40) or detachment of the ciliary border of the iris, is always accompanied by blood in the anterior chamber (hyphæma), and in consequence the rent is often not seen till the blood is absorbed. The pupillary edge corresponding to the rent is flattened, as in fig. 40. If the rent is large, the edge of the lens, suspensory ligament, and ciliary processes may be seen; the patient may experience some trouble from thus possessing two pupils. The treatment is atropine drops to dilate the pupil, as in some cases re-attachment may take place.

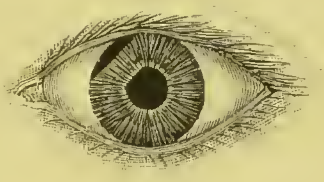


Fig. 40.—Irido-dialysis

Small rents in the pupillary border may occur, producing considerable hyphæma.

Retroversion of the iris, complete or partial, may ensue, and the iris may be seen doubled on itself or even lost to view.

Irido-donesis (ιρις, iris; δονέομαι, I vibrate), or tremulous iris, is occasionally found, and is due to the iris losing its support owing to dislocation of the lens or to fluid condition of the vitreous.

2. **Results of perforating wound of the eyeball.** *Rupture*, or lacerated wound of the iris, which, as a rule, is complicated with injuries to the lens. *Prolapse* (hernia) of the iris through a wound of the cornea or sclerotic. The treatment in these cases is to wash the wound with an antiseptic lotion, as boracic acid, and to remove the prolapsed portion by drawing the iris out with a pair of

iridectomy forceps and cutting off the portion of iris. The wound should be freed from the cut edges of the iris by a curette, and the eye tightly bandaged up. Atropine or eserine should be dropped into the eye according to the position of the wound. If the prolapse is uncomplicated by injury to the lens, and is seen within an hour or so of the injury, the prolapsed iris may be returned into the anterior chamber by a spatula, and eserine or atropine drops applied.

CHAPTER VIII

THE PUPIL

Physiology.—The description of the aspect, size, activity, shape and position of the normal pupil will be found on p. 10, and should be referred to on reading this chapter. In order to explain the pupillary movements, the chief physiological experiments on the pupil are mentioned below, and are mainly on the unstriped muscular fibre and the nerves of the iris, though the vascular supply exerts a marked influence on the pupil.

Muscle.—The unstriped muscular fibre of the iris is found as a circular band (sphincter pupillæ) arranged in bundles surrounding the pupil. Other muscular fibres have been described lying close to the posterior limiting membrane of the iris, and arranged in a radial manner from the sphincter towards the peripheral attachment of the iris. These have been called the dilator of the pupil, but I have never seen any fibres that could be compared in thickness with the sphincter pupillæ, or capable physically of overcoming the sphincter fibres and producing dilatation of the pupil. Under the term pupillary muscle I have here included all the muscular fibres of the iris. This muscle, like the unstriped muscular fibre of the intestine and vessels, is supplied by two sets of nerve fibres.

Nerves.—The one set (miotic) on being stimulated produce contraction of the pupil (miosis, *μειωσις*, decrease),

and the other set (mydriatic) cause dilatation of the pupil (mydriasis).

The *miotic* tract, starting from the nucleus of the third nerve in the floor of the aqueduct of Sylvius, accompanies the third nerve and reaches the lenticular ganglion by its short root; from the ganglion it is distributed by the short ciliary nerves to the pupillary muscle.

The *mydriatic tract* may be traced from the centre in the medulla oblongata down the spinal cord as far as the second dorsal nerve, and then follows the communicating branch of the second dorsal nerve to the cervical splanchnics, thus reaching the plexus around the internal carotid artery; from this plexus it passes to the naso-ciliary branches of the nasal nerve, which as the long ciliary nerves supply the pupillary muscle with mydriatic fibres. The course of these two sets of nerves has been examined by anatomical, histological, and physiological methods.

The effect of stimulating any part of the *miotic tract* is to give rise to extreme contraction of the pupil (pin-point pupil); the effect of section of any part of the tract is to produce a moderately dilated pupil inactive to the pupillary reflexes.

In the same way the result of stimulating the mydriatic tract is to produce an ad maximum dilatation of the pupil, and section of any part of this tract is followed by a moderate contraction of the pupil. Stimulation or section of the mydriatic tract does not abolish the pupillary reflexes.

The effect, therefore, of stimulation of either nerve tract is to produce an extreme contraction or dilatation of the pupil, but section of either tract gives rise to only a moderate dilatation or contraction. This latter or moderate effect is to be explained by the tone the pupillary muscle possesses. After section of its nerves it still responds to direct stimulation of the muscular fibre;

thus direct stimulation near the pupillary border of the iris is followed by contraction of the pupil, whereas excitation towards the ciliary border produces dilatation of the pupil.

From these experiments it will be seen that the nerves (miotic) causing contraction of the pupil evidently preside over the reflexes, as on complete section in any part of their tract the pupil no longer responds to them These reflexes have been described on p. 10, and are light, accommodation, and sensory. The above experiments on the pupillary nerves only concern the efferent nerves, and it is therefore necessary now to consider the afferent fibres of the reflexes. The *afferent fibres of the light reflexes* are first the optic nerves, and it is probable that the afferent pupillary reflex fibres are not the same as the visual fibres of these nerves. By the optic nerve the afferent pupillary reflex fibres pass to the chiasma and then by the optic tract of the same side (perhaps also by the opposite tract) they reach the nucleus of the third nerve. Section of the optic nerve and the afferent tract abolishes the light reflex.

Direct light pupillary contraction reflex.—The stimulus producing the contraction of the pupil of the same side by light thrown into an eye takes the following course: from the optic nerve by its pupillary reflex fibres to the optic tract of the same side, and so to the centre in the floor of the aqueduct of Sylvius; from this centre it is transmitted by the third nerve, the lenticular ganglion and the short ciliary nerves to the pupillary muscle.

The *consensual light pupillary contraction reflex* is produced by light thrown into one eye, causing contraction of the pupil of the other eye. The afferent tract of the reflex is the same as the direct light reflex, but the stimulus on reaching the centre is transferred to the opposite third nerve nucleus, and so by means of the

short ciliary nerves to the pupil of the opposite eye. This reflex takes place as long as the optic nerve of the eye stimulated by increased light and the third nerve on the opposite side are intact.

The *accommodation contraction reflex* takes place on fixing a near object or on converging the eyes as if accommodating. The afferent fibres of the reflex are usually the visual fibres of the optic nerve, but may be, as in the blind, the sensory nerves supplying the convergent muscles. The centre is situated in the floor of the aqueduct of Sylvius, and the efferent fibres are the short ciliary nerves through the third nerve.

The *sensory dilatation reflex*, which is obtained by stimulating a sensory nerve, as by tickling the hand, is probably due to an inhibition of the miotic fibres of the pupil, and is lost on section of the third nerve.

Vessels.—If the blood supply of the iris is increased, as by dilatation of the vessels, the pupil is contracted (congestion miosis); this is well seen on tapping the anterior chamber. Dilatation of the pupil occurs if the blood supply of the iris is reduced, as after severe hæmorrhage or contraction of the blood-vessels.

Action of drugs on the pupil.—The drugs acting locally on the pupil may be divided into three groups—atropine, cocaine, and eserine (physostigmine).

The *atropine* group produces mydriasis or dilatation of the pupil, which is inactive to the various reflexes.

The *cocaine* group also causes mydriasis, but the pupil still acts to the several reflexes.

The *eserine* group is characterised by miosis, the pupil still reacting to the reflexes.

Atropine.—The local action of atropine on the pupil is to paralyse the unstriped pupillary muscle and thus produce mydriasis. The atropinised pupil does not react to the light, accommodation, or sensory reflexes, and the mydriasis is larger than that produced by section of the

third nerve. Eserine has no effect on complete atropine mydriasis, but cocaine as a rule increases the size of the atropinised pupil. Other mydriatics belonging to this group are homatropine, daturine, duboisine, hyoscyamine, hyoscine. Of these homatropine is the most frequently used, as its action is quicker, weaker, and less lasting than atropine, and the effect can always be overcome by eserine. In cases where atropine produces symptoms of irritation, and homatropine is not effective enough, daturine may be employed.

Cocaine acts by stimulating the endings of the mydriatic or long ciliary nerves, and produces an ad maximum mydriasis, but the pupil always acts to the light and accommodation reflexes;[1] atropine used with cocaine stops the action of the pupil to light and accommodation, but does not necessarily increase the size of the mydriasis; the combination of the two drugs produces quicker dilatation of the pupil than atropine alone. Eserine easily overcomes the cocaine mydriasis.

Eserine produces extreme miosis and acts here as elsewhere on the body by stimulating the unstriped muscular fibre; the eserinised pupil still acts to light, and dilates on shading. Eserine miosis is overcome by atropine if the latter be used of sufficient strength, and long enough. The effect of the antagonism of atropine and eserine is that eserine acts as long as the unstriped muscular fibre is not completely paralysed, but if the pupil be thoroughly under atropine it has no effect. Eserine always overcomes cocaine mydriasis. The other local miotics act like eserine, by stimulating the pupillary muscle—namely, pilocarpine, nicotine, and muscarine. Of these pilocarpine is the only one used, and is much weaker than eserine (about 1 : 7). The use of eserine is generally attended by

[1] *Proceedings of the Royal Society*, 1885, p. 439.

pain, owing to the cramp produced by contraction of the intra-ocular muscles.

The pupil in health.—*Size and activity.*—The size of the pupil varies with the amount of light, state of accommodation, and also the general condition of tone of the patient. The pupils are frequently in health slightly different in size. Age tends, after forty-five years, to diminish the pupillary aperture, and the action of atropine and cocaine is less marked, though the effect of eserine remains the same. The changes in size of the pupil consequent on the reflexes are best seen by taking a normal example (the measurements are given for the right pupil): *Light reflex* (daylight).—Both eyes open, 4 mm.; left eye closed, 4·5 mm.; left eye closed and then opened, 3·5 mm. at first, and afterwards 4 mm.; both eyes shaded, 5 mm. *Accommodation reflex* (daylight).—Looking down and in, both eyes open, 2·25 mm.; left eye closed, 3·25 mm.; relaxation of accommodation, 4 mm.; looking externally, 4·5 mm., and on relaxation of accommodation, 5 mm.; sensory reflex up to 5 mm.

Associated actions of the pupil.—On every convergent movement of a normal eye the pupil contracts, and on the eye becoming parallel again the pupil dilates, and regains its former size.

In some rare cases the pupil dilates markedly with all external movements; this is seen in some cases of paralysis of the external rectus, in which forced attempts at external movement are followed by dilatation of the pupil. During conjugate deviation of the eyes the pupils as a rule are the same size. With the act of accommodation the pupil contracts, and this is best seen when the eye is directed down and inwards; on looking outwards and accommodating it is scarcely noticeable. On relaxation of accommodation the pupil dilates markedly.

Shape and position.—The pupil is generally circular, its centre being slightly to the nasal side of the centre of the cornea. A dilated pupil is frequently oval, when the long diameter is as a rule vertical; the smaller the pupil the less likely it is to be circular.

Sleep.—The condition of the pupil is miosis, which is greatest during deep sleep. It is due to central stimulation, and not only to the usual convergent position of the eyes. The fully atropinised pupil is unaffected during sleep, but cocaine mydriasis is overcome and miosis ensues.

The *normal pupil* should be regular in shape, size, and position, and should pass the following tests: Direct and consensual light reflex, sensory reflex, movements associated with accommodation, convergence, divergence and conjugate deviation of the eyes, action of the two classes of mydriatics (atropine and cocaine), and also of a miotic as eserine.

Drugs influencing the pupil when taken internally and not acting locally are chloroform, morphine, strychnine, curare, and quinine.

Chloroform.—During the administration of this drug for anæsthetic purposes, the pupils vary according to the stage of anæsthesia. In the excitement stage the pupil is dilated (acting to light); in the stage of anæsthesia, it is contracted; but if the drug be now pushed to a dangerous point the pupil dilates and is motionless to light. If the eyes are fully under atropine or eserine beforehand, no effect on the pupil is observed; but during the ordinary anæsthetic stage the pupil often contracts if the eyes are under cocaine.

Morphine given internally produces bilateral miosis (acting to light); but has no effect on a fully atropinised eye. It acts on the centres for the contraction of the pupil and not on the peripheral endings of the nerves or muscles.

Strychnine.—Poisonous doses of this drug produce dilatation of the pupil, due to stimulation of the medullary mydriatic centre, owing to deficient aëration of the blood, as on artificial respiration the pupil returns to the normal condition.

Curare.—The mydriasis following poisoning by this drug is due to the same cause as that produced by strychnia. In birds curare acts directly on the striped muscle of the iris by paralysing it, and so producing mydriasis.

Quinine.—In large doses this drug produces a bilateral mydriasis due to contraction of the blood-vessels.

Pathological states of the pupil.—Most of these may be classified under isocoria (ἴσος, equal; κόρη, pupil) or anisocoria (ἄνισος, unequal; κόρη, pupil), and each class may be further subdivided into mydriasis and miosis.

Isocoria (equal pupils).—I. *Mydriasis*: A. Acting to light and accommodation. B. Not acting to light or accommodation. C. Acting to accommodation but not to light.

A. (1) May be due to stimulation of both mydriatic tracts, generally central as by strychnia, or peripheral by cocaine. (2) Vasomotor, due to constriction of blood-vessels and general bloodlessness. (3) Stimulation of a sensory nerve. (4) Violent muscular exercise.

B. Destruction or palsy of both miotic tracts or pupillary muscles, usually nuclear (cerebral hæmorrhage or tumours) or peripheral (blows and drugs), and some cases of blindness following disease of optic nerves.

C. Cases of locomotor ataxy.

Certain diseases have frequently bilateral mydriasis as a symptom. Enteric fever, aortic insufficiency, commencing insanity, meningitis (after initial contraction), cerebellar disease, hydrocephalus, helminthiasis, epilepsy (tonic stage), migraine, and middle meningeal hæmorrhage.

II. *Miosis*: A. Acting to light and accommodation. B. Not acting to light or accommodation. C. Acting to accommodation and not to light.

A. (1) Paralysis of both mydriatic tracts, chiefly central (Cheyne-Stokes breathing). (2) Stimulation of both miotic tracts (morphia) or both pupillary muscles (eserine, pilocarpine). (3) Vascular congestion of irides, as in fevers, &c. (congestion miosis).

B. Locomotor ataxia.

C. Locomotor ataxia.

The chief diseases characterised by bilateral miosis are hæmorrhage into the upper part of the pons, general paralysis of the insane, meningitis, anæmia of the brain, paralysis agitans, venous obstruction as in mitral regurgitancy, pneumonia, typhus, variola, algid state of cholera, epilepsy (sometimes at commencement), anterior-polio-myelitis.

Anisocoria (unequal pupils).—Cases of anisocoria may be divided into two groups, the one in which one pupil is normal, and the other in which both are abnormal.

Anisocoria (one pupil normal).—I. *Mydriasis*: A. Acting to light and accommodation. B. Not acting to light or accommodation. C. Acting to accommodation and not to light.

A. (1) Stimulation of one mydriatic tract in any part of its course. (2) Increased intra-ocular tension. (3) Cyclitis.

B. Paralysis of one miotic tract or pupillary muscle.

C. Rare cases, showing the Argyll-Robertson pupil in only one eye.[1]

II. *Miosis*.—A. Acting to light and accommodation. B. Not acting to light or accommodation. C. Acting to accommodation and not to light.

A. (1) Paralysis of one mydriatic tract at any part of

[1] *Trans. Ophth. Soc.*, vol. xi. p. 179.

its course. (2) Stimulation of any part of one miotic tract or of one pupillary muscle. (3)Vascular congestion of iris due to iritis, diminished intra-ocular tension, &c. (4) Reflex by painful stimulation of the fifth nerve, as in keratitis, iritis, and other ocular diseases.

B. Complete posterior synechia.

C. Very rare cases, showing uniocular Argyll-Robertson pupil.

Unequal pupils are often found in cases of apoplexy, meningitis, chronic and acute alcoholism, general paralysis of the insane, locomotor ataxy.

Hippus.—This is a condition of the iris characterised by choreic spasms, producing rapid contraction and dilatation of the pupil. These movements are independent of light or the position of the eye, and are seen in cases of epilepsy, mania, general paralysis of the insane, cerebellar tumour, &c. Hippus may be associated with nystagmus, especially when of central origin.

CHAPTER IX

DISEASES OF THE CILIARY BODY

Anatomy and Physiology.—The ciliary body is the portion of the uveal tract situated between the iris and the choroid, and is in fact the anterior portion of the choroid. It is divided, like the iris, into a mesoblastic and an epiblastic portion. The mesoblastic portion, forming the chief part of the ciliary body, contains the ciliary muscle, which is composed of unstriped muscular fibre, having its origin in a tendon attached to the sclerotic near the ligamentum pectinatum iridis. The muscular fibre is disposed in different directions; some fibres (*longitudinal*) pass backwards to be inserted into the choroid, others have an *oblique* direction, and the anterior fibres are arranged in a *circular* manner. The disposition of these fibres is probably due to the position of the ciliary body; in the hypermetropic, or short eye, the fibres appear more circular, and in the myopic, or long eye, they are chiefly longitudinal. As in the case of the pupillary, it is best to describe the fibres of the ciliary muscle as forming one muscle supplied by two nerves; the third nerve producing contraction, and the sympathetic, relaxation of the muscle. The main action of the ciliary muscle is to effect accommodation by its influence on the suspensory ligament of the lens. The physiological experiments are analogous to those on the

pupillary muscle. Stimulation of the third or short ciliary nerves produces contraction of the muscle and has for its result accommodation, whilst section of these nerves gives rise to paralysis of the muscle and abolition of the power of accommodation. Stimulation of the long ciliary nerves produces relaxation of the muscle and paresis of accommodation. The third is evidently the chief motor nerve, as on section of this nerve accommodation is impossible except by direct stimulation of the muscle, as by eserine. The local action of drugs on the ciliary muscle is the same as on the pupillary, but, as the former is larger, the action is not so lasting or so great. The *atropine* group paralyses the muscle, causing paralysis of accommodation. *Cocaine* induces relaxation of the muscle by stimulating the endings of the long ciliary nerves, and by this means causes paresis of accommodation for a short time. *Eserine* produces spasm of the muscle by direct stimulation of the muscular fibre, and as a result, spasm of accommodation. Eserine easily overcomes the action of cocaine, but has no effect on the fully atropinised ciliary muscle.

The vessels of the ciliary body are derived from the long ciliary and perforating arteries, and form at the periphery of the iris the circulus arteriosus iridis major; the veins convey the blood to the venæ vorticosæ.

The nerves form a plexus with ganglion cells, and are derived from the long and short ciliary.

There is a lymphatic space between the ciliary body and the sclerotic. Pigment cells are found in the connective tissue, but are not so abundant as in the choroid.

The epiblastic portion is thrown anteriorly into folds, the so-called ciliary processes. This portion is lined by an external layer of black pigment cells continuous with the pigment layer of the retina and iris, and an internal layer continuous with the ciliary portion of the retina, assisting in the formation of the suspensory ligament of the

lens. Treacher Collins [1] has described a series of tubular secreting glands in the ciliary processes, which probably secrete the nutritive fluid for the vitreous.

CYCLITIS (κύκλος, circle) or inflammation of the ciliary body exists usually as part of a general uveitis, but may be found as a separate disease. The characteristic *symptoms* are neuralgic pain and tenderness over the ciliary region; this pain is especially marked during the movements of accommodation. The *signs* are the presence of deposits on Descemet's membrane (fig. 27), vitreous opacities, deep anterior chamber, and, as a rule, a dilated pupil. Cyclitis may be divided into catarrhal, plastic, and purulent.

Catarrhal (*serous*) **cyclitis** has been variously described under the names of serous iritis, keratitis punctata, aquo-capsulitis and descemetitis. It is usually found in young adults, especially females, is very protracted in its course, and tends to relapse.

The symptoms, varying very much in severity with the attack, are neuralgic pain, especially on accommodating; tenderness in the ciliary region; photophobia, lachrymation, and diminution of acuteness of vision.

The *signs* are circumcorneal zone; punctate deposits of different sizes on Descemet's membrane; deep anterior chamber, and turbid aqueous; dilated pupil; increased intra-ocular tension and vitreous opacities.

It usually affects one eye at a time, though the other suffers as a rule sooner or later. The course is extremely slow, and the punctate corneal opacities may be found even years afterwards.

The *complications* are iritis, scleritis, peripheral choroiditis, and glaucoma.

It is often associated with a history of gout, rheumatism, anæmia, menstrual trouble, or tubercle.

[1] *Trans. Ophth. Soc.*, vol. xi. p. 55.

Inflammation of the ciliary body, especially the glandular portion, is accompanied by proliferation and detachment of small cells, which pass into the anterior aqueous chamber through the pupillary aperture. They are then deposited on Descemet's membrane in the form of a conical bullet (fig. 27) with the apex upwards and near the centre of the cornea; this shape is owing to the combined effects of gravity and the continuous flow of the aqueous fluid towards the angle of the anterior chamber.

It is often mistaken for iritis, but can generally be *diagnosed* by the dilated pupil and marked punctate corneal deposits.

The *prognosis* is good as long as the rest of the uveal tract is not seriously implicated.

The *treatment* is complete rest for the eyes; tinted glasses or goggles; atropine drops, unless, as occasionally happens, they give rise to great pain or increased tension, in which case eserine may be used; leeches if pain continues severe; paracentesis of the anterior chamber if tension keeps high; general constitutional treatment by tonics, as cod-liver oil and iron.

Plastic cyclitis follows injuries of the ciliary region; operations such as cataract extraction, owing to entanglement of the base of the iris in the wound; presence of *débris* of the lens, or dislocation of the lens; it is found in an idiopathic form in tubercular and syphilitic subjects.

The disease is seldom if ever limited for more than a short time to the ciliary body, but tends to spread through the whole uveal tract as a plastic uveitis. It is usually accompanied by more severe symptoms than the catarrhal form, but may occasionally be very chronic. The pain and tenderness in the ciliary region are marked; the congestion of the episcleral blood-vessels may be so extreme as to cause the case to be mistaken for scleritis. The punctate deposits in the anterior chamber are larger and

more granular looking, and they tend to coalesce and in some cases to form a mass of lymph in the lower part of the anterior chamber. Vitreous opacities are always present.

Treatment is the same as in catarrhal cyclitis, but mercury is often indicated.

Purulent cyclitis may occur without direct external infection, but is generally consequent on an infective ulcer of the cornea or a septic wound (traumatic or operative) of the ciliary region. The external signs of inflammation are generally well marked, the eyelids being swollen, and the conjunctiva congested and chemosed. There is great turbidity of the vitreous and aqueous humours, and pus in the anterior chamber (*hypopyon*). The tension may be increased. In young children the pus usually becomes quickly absorbed, but in adults it may remain for days causing iritis and other complications.

It is a septic inflammation of the ciliary body with the formation of pus, which finds its way through the pupil to the most dependent part of the anterior chamber. The disease generally yields to *treatment*, which should consist of fomentations of belladonna (F. 4) or poppyheads (F. 39); atropine drops (F. 1); bandaging; in obstinate cases in adults, paracentesis of the anterior chamber and evacuation of the pus are indicated. If there be a wound or infective ulcer, it should be actively treated by cauterisation, iodoform, or antiseptic lotions.

A tumour of the ciliary body at first grows posteriorly towards the vitreous chamber, but may push forward the iris and thus narrow the depth of the anterior chamber. It can sometimes be seen by the ophthalmoscope, if the pupil is dilated, at the extreme periphery of the fundus as a dark rounded swelling. It is generally a melanotic sarcoma, either round or spindle celled (p. 159). Primary carcinomata and innocent adenomata, originating from the ciliary glands, and myomata have been

recorded. The treatment of a ciliary tumour is to excise the eye.

Affections of the ciliary muscle.—The action of the ciliary muscle enables the eye to accommodate for near vision. After forty-five the muscular fibre tends to degenerate, and thus produces, with the diminution of elasticity and growth of the lens, defective accommodation, and presbyopia (old sight).

Occasionally in young people *spasm* of the ciliary muscle occurs, giving rise to apparent myopia, but the usual pathological conditions are those of *paresis* or *paralysis*. In complete paralysis of the third nerve the ciliary muscle is also paralysed. In diphtheria, paralysis or paresis of both ciliary muscles may be present without any affection of the pupillary or other muscles of the eye, and is probably a nuclear lesion.

Paralysis or paresis of the ciliary muscle has been found in cases of pregnancy, lactation, anæmia, mumps, diabetes, and as a sequela of fevers: this condition is probably due to deficient blood-supply and want of muscular tone. The muscle may sometimes be paralysed as the result of a blow on the eye.

The local treatment is atropine for spasm of accommodation, and eserine or pilocarpine for paresis or paralysis.

CHAPTER X

DISEASES OF THE CHOROID

Anatomy.—The choroid is the posterior part of the uveal tract situated behind the ciliary body; its functions are to nourish the pigmentary layer of the retina. It is adherent to the sclerotic around the optic nerve entrance, but elsewhere is only loosely attached to this membrane. It is separated from the sclerotic by a lymph space and is composed from without inwards of: (1) *lamina suprachoroidea,* consisting of branched connective tissue cells and elastic fibres; (2) *lamina vasculosa,* formed by arteries, veins, and numerous pigment cells; (3) *lamina chorio-capillaris,* comprising a close network of capillaries; (4) *lamina vitrea,* a hyaline membrane lying next to the pigmentary layer of the retina. The epiblastic layer of uveal pigment continuous with that of the iris and ciliary body is not described as part of the choroid, as by its development it belongs to the retina. The connective tissue of the choroid consists of elastic fibres and numerous branched pigment cells. The vascular supply is from the short posterior ciliary arteries (fig. 2, S. CIL.) and the venæ vorticosæ (fig. 2, V.V.) are the emissary veins. The nerve supply is derived from the long and short ciliary nerves.

CONGENITAL DEFECTS.—*Coloboma* is a developmental defect in the choroid, as a rule situated below the optic disc, and generally associated with some other

congenital abnormality of the eye, as coloboma of the iris When examined by the ophthalmoscope, it appears as a bright white triangular patch, bordered by black pigment, depressed below the general surface of the fundus, and having a rounded apex at or above the optic disc. The white colour is due to the sclerotic being visible owing to absence of the choroidal pigment. The retinal vessels cross it, but as the retina is also imperfectly developed, there is an absolute or relative scotoma corresponding to the area of the coloboma.

Albinism is the term applied to the condition when the pigment of the uveal tract is wanting, and is associated with a lack of pigment elsewhere in the body. The pupil appears reddish-pink instead of black, and the iris pink. The fundus is pale, and its choroidal vessels very distinct. Vision is defective, and nystagmus and ametropia are generally present. With increase of years there is a tendency to deposition of pigment. The photophobia, which is usually present, is relieved by wearing tinted glasses in bright lights.

CHOROIDITIS, or inflammation of the choroid, is rarely met with unless the retina is also implicated, owing to the proximity and close relationship of these structures. For this reason nearly all cases of choroiditis would be better described as choroido-retinitis. It must therefore be understood that in the following description of choroiditis, the inflammation occurs primarily in the choroid, though the retina is secondarily involved. Choroiditis may be divided into two forms: plastic (non-purulent) and purulent. Severe pain or external signs are only present, as a rule, in the purulent form, or in cases where the disease is part of a more general inflammation.

Plastic (*non-purulent or exudative*) **Choroiditis** is characterised by certain general signs and symptoms apart from the special features of its varieties.

The *symptoms* consist of disturbances of vision, the intensity of which depends on the situation of the choroidal disease, the extent of implication of the retina and the condition of the vitreous. In the early stages, flashes of light, bright sparks before the eyes, and halos around lights occur; in the later, there may be scotomata and contraction of the fields of vision. Choroiditis may be very extensive and gross in pigmentation without any effect on the vision.

The *signs* are only to be seen by means of the ophthalmoscope, and consist of localised patches of effusion which render the involved surface of the fundus uneven and indistinct. The more recent patches vary in size and position, are soft-looking, yellowish-white or grey, with ill-defined edges. After absorption of the effusion, which may take many months, there remains a definite area of atrophied choroid. If *superficial*, this patch is yellowish in colour, with the choroidal vessels well seen. If *deep*, it is opaque white, owing to exposure of the sclerotic, and the edges are fringed with black pigment; such patches of atrophied choroid are ringed, diffuse, or punctate in shape.

The pigment found in choroiditis is dark brown or black in colour, very irregular in shape, often like ink blots, and much heavier-looking and more deeply seated than retinal pigment. The retinal blood-vessels lie superficial to the effusions, pigment, and atrophied patches in the choroid. Vitreous opacities are frequently present, and the retina is as a rule involved.

Complications and sequelæ.—There may be inflammation of the iris, retina, and sclerotic; as a result of the last, some form of bulging (staphyloma) may ensue. Optic neuritis, vitreous opacities, and posterior polar cataract also occur. *Causation.*—In many cases there is no apparent cause; some are the result of syphilis (acquired or hereditary), tubercle and anæmia. Choroiditis is

found in myopia, disease of the central nervous system, and after hæmorrhage into and injury of the choroid. *Pathology.*—Microscopic examination of a recent patch of choroiditis reveals an exudation of small round cells confined to the inner (capillary) layer of the choroid; in tubercular cases giant cells, and sometimes tubercle bacilli are found. At a later stage, the pigment cells proliferate and those beneath the exudation become absorbed, giving rise to the white patches; occasionally, some pigment cells persist and produce the black patches above spoken of. The adjacent layers of the retina are destroyed.

Diagnosis.—The recent patches are difficult to distinguish from those of retinitis, but the colour is more yellow and not so milk-white or opalescent, the effusion is deeper, and the retinal blood-vessels are superficial. In the later stages the presence of patches of opaque, white sclerotic, bordered by black pigment, makes the diagnosis easier.

Prognosis.—Atrophy of the choroid generally follows choroiditis, and the condition of vision depends upon the position of the changes.

The *treatment* common in all cases of choroiditis is to rest the eyes as much as possible, to use tinted glasses or goggles, and to avoid bright lights.

The special forms of plastic choroiditis are those occurring in syphilis, tubercle, high myopia, and old age.

Syphilitic choroiditis may be divided into acute and disseminated.

The *acute* form occurs as a rule in the secondary stage of acquired syphilis, and is accompanied by retinitis. The exudative patches are small, yellowish in colour, mostly near the periphery, which from the consecutive superficial atrophy presents a marbled or pebbly appearance. Vitreous opacities are always found, and the effusion is in the capillary layer of the choroid.

Disseminated choroiditis (Plate II. *a*) is the form in which

a

DISSEMINATED CHOROIDITIS.

b

RETINITIS PIGMENTOSA.

the foci of inflammation are scattered over the fundus, especially near the periphery. It is generally found in both eyes, and in acquired as well as in hereditary syphilis. It occurs at all ages, and may be present at birth. The choroidal changes consist of patches of pigment and discrete round white spots fringed by pigment (*ringed choroiditis*). The white colouration is due to the sclerotic showing through; some yellowish spots of superficial atrophy may be found in recent cases. These changes probably follow exudative choroiditis, but the early stage is not as a rule seen. When the disease is limited to the periphery the vision may be unaffected, but if the yellow spot area is implicated, acuity of the vision is much reduced. The retina is generally involved, and with the optic disc, may become atrophied; vitreous opacities are generally present.

The constitutional treatment is mercury, administered either by inunctions or by the mouth. Iodide of potassium or iodide of ammonium may also be given alone, or in combination with mercury. In acute cases, atropine drops may be used to keep the iris and ciliary muscle at rest.

Myopic choroiditis (fig. 41).—Owing to the increase in length of the myopic eye and the thinning and bulging of the sclerotic in the neighbourhood of the optic nerve entrance, stretching of the choroid takes place. The effect of this is mostly seen at the temporal side of the disc as a myopic crescent (Plate IV. *b*) or posterior staphyloma.

In high myopia (fig. 41) there is usually a mottled and striped appearance due to thinning of the choroid; atrophic choroidal patches may be found, generally at the outer side of and near the disc, and are irregular in shape with pigmented edges. In some cases, yellowish-white zigzag lines may be seen in the choroid, and are a grave sign, denoting active stretching of the choroid. At the yellow spot there may be sooty pigment changes.

Myopes, during the active stage of choroiditis, complain of dull aching pain in the eyes, cloudy vision, floating spots before the eyes, and metamorphopsia.

Mercurial treatment is frequently beneficial in these cases, when the choroidal changes are progressive. The general health must be carefully studied, especially as to the hygienic surroundings. Atropine drops (F. 1) should be ordered, and at times leeches and blisters.

Tubercular choroiditis [1] appears in two forms: (1) as small miliary tubercles, pale pink or white in colour,

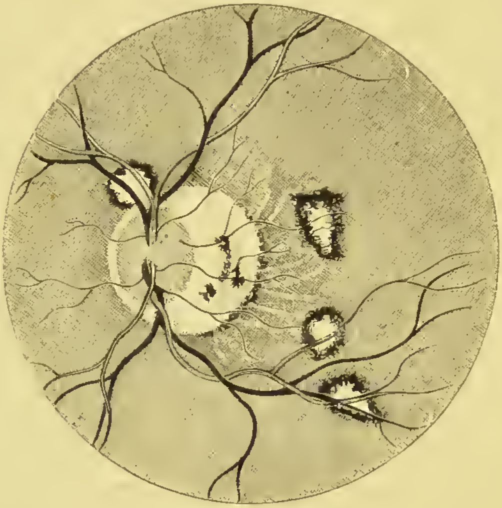


Fig. 41.—Myopic Choroiditis

surrounded by retinal haze and œdema, and situated near the disc and yellow spot; these are of diagnostic importance only, as they are met with in the course of acute miliary tuberculosis and tubercular meningitis; (2) as a solitary tubercular mass, generally at the yellow spot, which may be mistaken for glioma.

The tubercular patches are found in the deep layers of the choroid, and though giant cells are always present,

[1] Mules, 'Tubercle of Choroid,' *Trans. Ophth. Soc.* vol. iv. p. 160, Plate VII. fig. 1.

tubercle bacilli are rarely found. Treatment is of no avail.

Senile choroiditis.—In people over sixty years of age changes are frequently to be found in the choroid about the yellow spot region, and are often the cause of the bad sight following extraction of cataract. For this reason it is very important that the yellow spot region should be carefully examined in all cases of incipient senile cataract. In many cases this choroidal change is black and mottled (sooty choroiditis) or appears as a light yellowish patch. Two other forms have been described:—one, a large depressed circular superficial patch with the choroidal vessels running across and giving it a striped appearance; the other, first described by Tay and known as *central guttate choroiditis*, consists of small glistening yellowish-white scattered spots [1] without pigmentation, due probably to deposits in the superficial layers of the choroid.

Treatment is useless.

Purulent choroiditis, which is very acute in its onset, is marked by œdema and swelling of the lids, with chemosis and infiltration of the subconjunctival and orbital tissues producing proptosis. Iritis is usually present, and vitreous opacities obscure a view of the fundus. A yellowish deep reflex may be seen, due to purulent infiltration, to which the name *pseudo-glioma* has been given. There is great pain in these cases and rapid loss of vision; they generally develop into panophthalmitis, though they are sometimes limited to the choroid, ciliary body, and iris.

The most common cause is sepsis following a wound of the eyeball; but it also results from metastasis in pyæmia, septicæmia, and cerebro-spinal meningitis.

MALIGNANT TUMOURS of the choroid are almost entirely confined to sarcoma; carcinoma occurs rarely

[1] *Trans. Ophth. Soc.* vol. iv. Plate II. fig. 2.

as a secondary deposit, and cannot be distinguished from sarcoma before removal of the eye. By the ophthalmoscope, a choroidal sarcoma in the *first* or early stage is seen as a fixed prominence of a brown or opaque white colour beneath the retina. It is usually situated near the posterior pole of the eye, and may be lobulated; the retinal vessels pass over it, and there may be hæmorrhages and black pigment patches in the retina covering it, and simple detachment of the retina in its proximity.

The *symptoms*, which vary greatly according to the situation of the tumour, are diminution of visual acuity, scotomata, and flashes of light and sparks before the eyes arising from choroidal irritation.

The intra-ocular tension during this stage is normal or may be increased.

The tumour, in its growth, detaches the retina around it, and spreads to the neighbouring tissues (*second stage*), especially invading the vitreous chamber, and, pushing the lens and iris forwards, produces increased tension with signs of inflammatory glaucoma.

The after history and treatment are given under 'Sarcoma of the uveal tract' (p. 159).

Diagnosis.—Tumour of the choroid in the *first* stage may be mistaken for simple detachment of the retina, glioma, pseudo-glioma, or solitary tubercle. From simple detachment of the retina, it may be diagnosed by its fixed position, more solid and less transparent look, presence of pigmentation near vessels, and absence of a history likely to produce detachment. The intra-ocular tension may be a little increased, whereas in simple detachment the tension is normal or lowered.

From glioma, the chief differences are its occurrence in adults and not in children, and the presence of pigmentation.

From pseudo-glioma, the absence of signs of iritis and the increased tension distinguish it.

From solitary tubercle, the diagnosis is at first difficult, but there is a tendency to quickly break down in tubercle, rather than to increase rapidly in size.

In the *second* stage, the case is difficult to diagnose from glaucoma, especially when the lens is opaque, and many eyes have been excised for absolute glaucoma and a tumour afterwards found in them. In such cases, some of the conjunctival or muscular vessels are often enormously distended, and the perforating arteries may be enlarged and form new vessels on the iris.

Ossification of the choroid.—In an eye blind for a long time from plastic uveitis, especially when shrunken, a plate or shell of bone may be found in the choroid. It is usually part of a sphere with an oval aperture at the entrance of the optic nerve, and may be perforated by small vessels. The new bone is developed in the inflammatory tissue. The condition may be diagnosed sometimes by the hardness of the atrophied eye ; sympathetic inflammation has been produced by these osseous changes. The treatment is the removal of the eye.

Detachment of the choroid [1] from the sclerotic is rare and is usually only found after the eye has been removed. It may be due to hæmorrhage resulting from an operation with much loss of vitreous, serous exudation, or to a sarcoma. With the ophthalmoscope, it has been diagnosed by the choroidal vessels being seen beneath the retina covering the swelling. There is, as a rule, minus tension in these cases, which generally occur in shrunken eyes.

Rupture of the choroid is produced by a blow on the eyeball, and is at first accompanied by hæmorrhage from the choroidal or retinal vessels, which prevents a view of the injury.

After the blood has cleared up, the rupture is seen

[1] Marshall, 'Detachment of the Choroid,' *Trans. Ophth. Soc.* vol. xvi. p. 98.

as a narrow, yellowish-white, crescentic band, bordered by black pigment, and crossed by the retinal vessels. It is generally concentric with and in the neighbourhood of the optic disc. The vision is not much affected unless the rupture passes through the yellow spot region.

Treatment is to keep the patient in bed with the eyes bandaged for at least a fortnight, and the pupil may be dilated by atropine.

CHAPTER XI

DISEASES OF THE WHOLE UVEAL TRACT

UVEITIS or inflammation of the whole uveal tract has its origin, as a rule, in the ciliary body, and presents a combination of the chief signs and symptoms of cyclitis, iritis, and choroiditis. It comprises *plastic* uveitis, including sympathetic ophthalmitis, and *purulent* uveitis, generally called panophthalmitis.

Plastic uveitis may be divided into three groups of cases: (1) traumatic, (2) idiopathic, (3) sympathetic.

1. The *traumatic* class, as its name implies, follows an injury or wound of the eyeball and begins generally as plastic cyclitis (page 138), the inflammation gradually spreading to the iris and choroid. Though the course of the disease is generally more acute, it resembles so much in its main features the next class, that it may be considered with it.

2. The *idiopathic* form can be divided clinically into two groups, adult and infantile.

The *adult* group is found in both sexes between the ages of fifteen and thirty, though females are more liable to it. One eye only is affected at first, but the other usually follows suit. It is, as a rule, chronic, slow, and insidious in its course; the patients are generally of tubercular, syphilitic (hereditary), or rheumatic diathesis.

The first symptoms are those of plastic cyclitis (page 138) with well-marked punctate deposits on Descemet's

membrane. These are soon followed by iritis with numerous posterior synechiæ and frequently increased tension. Vitreous opacities, peripheral choroiditis, shrinking of the vitreous and detachment of the retina, diminution of tension and atrophy of the globe are the later stages of the disease, which may terminate in complete blindness.

The *infantile* group is met with in children from three months to four years of age, the subjects of hereditary syphilis, or suffering from one of the exanthemata as measles, or cerebro-spinal meningitis. The symptoms are generally at first acute with great swelling of the lids, deep ciliary congestion, iritis, and increased tension; the fundus cannot, as a rule, be illuminated. After the acute inflammatory stage the eye passes into an atrophic condition with diminished tension, shallow anterior chamber, pin point pupil, and generally complete loss of sight. A yellowish reflex is often to be seen through the pupil, and is due to lymph situated in the choroid behind the retina (*pseudo-glioma*).

Pathology.—There is a small cell infiltration of the whole uveal tract with formation of lymph, and subsequent fibroid change and contraction.

The *prognosis* in most cases is bad, and vision is generally much reduced and even lost. In the very chronic adult cases, the vision may be scarcely affected for some years, but a few punctate deposits are always to be found on the cornea.

The *treatment* is atropine drops, unless there be increased tension, when eserine or pilocarpine may be employed; fomentations and leeches are to be used when there is much congestion and pain. Iridectomy may be resorted to, but is generally unsatisfactory from the coloboma becoming filled with lymph. General constitutional treatment is indicated.

3. The *Sympathetic* class is usually described under

the name of **sympathetic ophthalmitis** (*sympathetic ophthalmia*), and is an inflammation of the uveal tract set up in one eye from the effect of inflammatory changes, generally of infective traumatic origin, in the other eye. The cases on record of sympathetic inflammation occurring without a perforating wound are very few and rare.

The eye originally affected is called the *exciting*, and the one secondarily attacked, the *sympathising* eye. It is an exceedingly serious disease and was formerly more frequently met with than now. This is mainly owing to surgical cleanliness, and its partial banishment is one of the triumphs of aseptic and antiseptic surgery. No ocular affection is to be more dreaded by the surgeon, as in almost every case the *sympathising* eye is left in a worse condition, as far as vision is concerned, than the *exciting*. It occurs at all ages, but is more frequently seen in the young than in the old.

Sympathetic ophthalmitis is, as a rule, but not always, preceded by a group of symptoms in the sympathising eye, to which the term *sympathetic irritation* has been applied. These must be carefully watched for in any case of severe injury to an eye, as by active treatment the more serious consequences may be warded off. The *symptoms* are dimness of vision, increased lachrymation and photophobia, accompanied by conjunctival congestion. The photophobia and lachrymation are out of all proportion to the objective signs; the dimness of vision may exist for all distances, but is more frequently due to defective accommodation, the patients complaining of asthenopia when using the eyes for close work. In order to avoid an error in diagnosis it is advisable to estimate the refraction and range of accommodation. Neuralgia along the frontal nerves may be present, and the patient may complain of seeing sparks and coloured lights. The pupil has been described as abnormally irritable and as oscillating more frequently than in health. In the

exciting eye the most marked symptom is tenderness over the ciliary region, combined with an irritable appearance of the eye itself.

Symptoms and signs of sympathetic ophthalmitis.—There is always a 'latent period' before the outbreak of sympathetic ophthalmitis, which usually varies from three to six weeks from the time of injury of the exciting eye, but cases have been known to occur as early as ten days, and as late as thirty years afterwards.

The first symptoms complained of in the sympathising eye are dimness of vision, photophobia and tenderness in the ciliary region; but these vary according to the severity of the disease, which may commence insidiously without any marked signs of inflammation.

The first signs to appear are circumcorneal injection and small punctate deposits on the posterior epithelium of the cornea, deep anterior chamber, and sometimes dilated pupil. The corneal deposits (fig. 27), which are nearly always present, must be carefully looked for with a high magnifying glass. They vary in size and number, are frequently rusty-coloured and flocculent, alter their position with that of the head if the latter remains for a lengthened period in one posture, and may be either scattered or arranged in the shape of a conical bullet with the apex upwards.

Some cases, by treatment, may not pass beyond the stage of cyclitis, or, at all events, cyclitis with slight iritis, but as a rule the plastic inflammation affects the whole uveal tract.

The usual *course* is that severe iritis ensues with great effusion of lymph, producing thickening of the iris stroma; the iris becomes yellowish-brown in colour, loses all trace of its markings, and new blood-vessels appear on its surface. The pupil is small, bound down by posterior synechiæ, and often obliterated by lymph. The anterior chamber, at first deep, becomes shallow and partly filled

with an exudation consisting of spongy lymph rather than pus. The lens usually becomes opaque.

The choroid is affected by the same plastic inflammation, but signs of choroiditis cannot be seen by the ophthalmoscope, owing to the inflammatory changes in the front part of the eye and in the vitreous. The vitreous contains numerous opacities and tends to shrink, causing detachment of the retina.

The intra-ocular tension, at first raised, becomes diminished, and the eye passes into the condition of general atrophy (*phthisis bulbi*).

Papillitis and retino-papillitis have been described as early signs, and whitening of the eyelashes has also been observed.

Causation.—Sympathetic ophthalmitis is probably microbic in its origin, and therefore is rarely found unless there has been a wound (traumatic or surgical) extending through the sclerotic or cornea of the exciting eye, but undoubtedly cases have been met with not resulting from a wound. It is probably necessary that there should be active inflammation of the uveal tract of the exciting eye at the onset of the sympathetic inflammation. The injuries most likely to be followed by this serious disease are jagged and perforating wounds in the ciliary region (fig. 31, *c*), especially if produced by a dirty instrument, as a fork or pair of scissors, and this danger is much increased if the lens be wounded or a foreign body be present in the eyeball.

It has followed operations, as cataract extraction, iridectomy, sclerotomy, but probably only when the base of the iris or the ciliary processes have been entangled in the wound; a few cases have been recorded after the operations of needling, abscission, evisceration, and excision. Among other causes are perforating ulcer, symblepharon, intra-ocular sarcoma, shrunken globe following panophthalmitis, plastic uveitis, and ossification of the choroid.

The changes in the sympathising eye are those of plastic uveitis, and generally start from the ciliary body, and thence throughout the whole uveal tract, though occasionally the disease may remain limited to its anterior portion. The exact method of the transmission of the disease from the exciting to the sympathising eye is still uncertain, but the nature of the disease, namely, plastic uveitis, is the same in both eyes. The most probable theory (Deutschmann) is that the disease spreads along the interior of the sheath of the optic nerve on one side to the chiasma, and then along the optic nerve of the other side; its mode of ingress into the sympathising eye is probably by the lymphatic tract. Experiments on injection of bacilli into the sheath of the optic nerve have demonstrated their passage as far as the optic nerve on the other side (Gifford). This theory would explain the transmission of the disease when infective material has been introduced into the exciting eye by a wound, but is difficult of explanation in cases in which the virus has lain dormant for twenty years, or where the excitant is an intra-ocular sarcoma. Another theory gives the blood-vessels as the means of conveyance of the disease (Berlin, Hutchinson), and reflex irritation through the ciliary and optic nerves has also been suggested.

The *prognosis*, if the whole uveal tract has become involved, is very unfavourable, and the eye as a rule becomes lost for useful vision and often completely blind. When limited to the anterior part of the uveal tract the result is generally very destructive to vision, but a few cases have recovered with good and occasionally even normal vision.

Treatment.—In cases of *sympathetic irritation* the condition of the exciting eye is first to be considered carefully, and the rule is to excise such an eye, remembering that sympathetic irritation is generally followed in time by sympathetic ophthalmitis. The only possible reason for not

excising in such a case is the possession of useful vision in the exciting eye. When *sympathetic ophthalmitis* has definitely commenced, its course can as a rule be little altered by excision of the exciting eye; if this eye be blind or have only perception of light it should be straightway removed. I would always excise the eye in such cases, and never do a partial operation, as abscission or evisceration. If, on the contrary, the exciting eye has fair vision, and is not in an active state of inflammation, it should be saved, as the probability is that the sympathising eye will be more seriously damaged than the exciting. The treatment of the sympathising eye (whether the exciting eye has been removed or not) is the same as that in a case of plastic uveitis. Atropine drops should be used several times a day, and the patient at first kept in bed, either in a darkened room or with his eyes protected by deep-tinted goggles. Unless otherwise indicated, he should be brought under the influence of mercury, preferably by inunctions; quinine may sometimes be given, or hypodermic injections of pilocarpine. If there be much pain and congestion, leeches should be applied to the temple or behind the ear. The treatment, owing to the disease lasting from six months to two years, is very prolonged, and the general health must be carefully attended to. Any operative procedure, as iridectomy, to improve the vision must be put off till all active signs of inflammation have ceased, otherwise the desired effect of the operation would be frustrated by exudation of lymph filling up any coloboma produced.

Purulent uveitis includes the class of cases generally described under the heading of *panophthalmitis*, and is characterised, as its name implies, by the presence of pus in the uveal tract.

The *symptoms* are very acute and the attack is ushered in by constitutional disturbance, such as fever, vomiting, &c. There is severe neuralgic and throbbing pain in

the brow, temple, and eye, and the vision is much diminished. The lids are swollen, red, and œdematous; the conjunctival and episcleral vessels are deeply congested; the conjunctiva is chemosed and the cornea has a dulled appearance. If there is a wound, it usually has a sloughy appearance, with a discharge of pus from it. Purulent iritis and cyclitis soon supervene with hypopyon

After a few days the eyeball is pushed forward and its movements are limited, owing to the inflammation spreading to Tenon's capsule; if the media are transparent enough a yellowish reflex can be seen, due to suppuration in the vitreous chamber. The iris is bulged forwards and the intra-ocular tension is much increased. If the disease is left to take its own course, the progress is slow and attended by great pain; after a time perforation occurs through the anterior portion of the sclerotic and pus is discharged through this opening, followed by immediate relief of the pain. The eyeball gradually shrinks until the eye becomes a small stump resembling a button. It is two or three months before the eye quiets down. In cases resulting from septic embolism both eyes may be attacked at the same time, but in those due to other causes only one eye is affected.

Causation.—It follows, as a rule, the introduction of septic material into the eyeball, either directly through a wound or perforation, but may, more rarely, be produced in cases of pyæmia by an embolus. Punctured and lacerated wounds of the eyeball, especially if complicated with the presence of a foreign body, are the most frequent cause; it may follow operation wounds such as extraction of cataract, and has resulted from a perforating or infective corneal ulcer. *Pathology.*—It generally commences by suppuration in the ciliary body or choroid, and the pus formed then detaches the retina and passes into the vitreous, giving rise to the yellow reflex, and the whole

eye becomes an abscess cavity, even the interior of the sclerotic coming away in sloughs.

Treatment.—There is practically no chance of saving the eye for useful vision. Incisions may be made through the cornea to give free vent to the pus, or the cornea may be removed by cutting round it with a knife or pair of scissors, and the contents of the eyeball cleared out, the cavity being filled up with absorbent cotton wool and iodoform. The eyeball, in my opinion, should never be excised during the inflammatory stage, as meningitis followed by death of the patient has been known to ensue.

Sarcoma usually has its origin in the choroid. Fuchs[1] out of 259 cases gives the starting point of 221 in the choroid, 22 in the ciliary body, and 16 in the iris. Lawford and Collins[2] in 103 cases give 94 as commencing in the choroid, 6 in the ciliary region, and 1 in the iris. The tumour is generally of the melanotic kind, but the pigment is sometimes very scanty and difficult to make out; it may be round or spindle-celled and often is very vascular. It occurs about equally in either sex and the usual age is between thirty and fifty; it is almost unknown in children and very rarely affects both eyes.

The course of an intra-ocular sarcoma is generally divided into four stages. In the *first* stage it is limited to the tissue it commences in. The *second* stage is when the growth spreads into the other ocular tissues and tends to fill up the cavity of the eyeball. A choroidal sarcoma as a rule grows posteriorly into the vitreous chamber and pushes the lens and iris forwards, producing generally a cataractous condition of the lens; a ciliary sarcoma usually grows backward into the vitreous, but may come forward into the anterior chamber, while sarcoma of the iris tends to fill up the anterior chamber. The

[1] Fuchs, E., *Das Sarcom des Uvealtractus.*

[2] Lawford and Collins, 'Sarcoma of the Uveal Tract,' *Roy. Lond. Ophth. Hosp. Rep.* vol. xiii. p. 104.

intra-ocular tension is increased during this stage and the eye may pass into a state of inflammatory glaucoma. The *third* stage is that in which the growth bursts through the structures of the eyeball, and this occurs either near the ciliary region, when the tumour will be seen beneath the conjunctiva, or more frequently the rupture is in the vicinity of the optic nerve and produces proptosis. When the growth extends along the optic nerve the brain and meninges may be affected. As soon as rupture of the eyeball has taken place the pain ceases, and the tension becomes minus. The *fourth* stage is that of metastasis, the secondary growths being most frequently found in the liver. The lymphatic glands near the eye are very rarely affected.

The *prognosis* as to life is bad if the tumour is of long standing, but if excision is performed during the first stage, there is a chance of the disease being eradicated. In untreated cases the prognosis will always be fatal and within five years of the commencement.

In the first and second stages of a sarcoma the *treatment* is immediate excision of the eyeball, care being taken that the optic nerve is divided as far back as possible; the only exception to the rule being in the case of a very small sarcoma of the iris, when the growth may be removed, with the part of the iris near it, by iridectomy.

In the third stage, the treatment is excision of the eyeball combined with removal of all the tissues of the orbit; and two days after the operation Vienna paste (F. 47) may be applied to the walls of the orbit.

CHAPTER XII

DISEASES OF THE RETINA

Anatomy and physiology.—The retina is a complex structure lying between the choroid and the hyaloid membrane enclosing the vitreous; it is developed in epiblast from both layers of the secondary optic vesicle. This vesicle consists of an anterior and a posterior layer, which extend from the optic nerve to the pupillary border of the iris. From the *posterior* is developed the uveal pigment layer which has been partly described as the epiblastic portion of the ciliary body and the iris. The portion of this layer extending from the ciliary body to the optic nerve is the pigment layer of the retina, consisting of hexagonal black pigment cells; it adheres closely to the choroid, from the capillary layer of which it is nourished. So close is this attachment that in detachments of the retina, and when the eye is opened for dissection purposes, the inner layers of the retina separate from the pigment layer which remains with the choroid.

From the *anterior* or inner layer of the vesicle is developed the connective tissue and nervous elements of the retina; the connective tissue (*neuroglial*) portion consists of the fibres of Müller, which form the internal and external limiting membranes. The nervous elements [1]

[1] The nervous layers are from within outwards: (1) *nerve fibres*, continuous with the optic nerve; (2) *nerve cells*; (3) *internal*

constituting the true retina extend from the optic nerve to a jagged border, the *ora serrata*, lying just behind the ciliary body.

On the surface of the retina the following points of importance may be observed: at the posterior pole of the eye is situated the *yellow spot* region, consisting of an oval area with a central depression, the fovea centralis, and 4 mm. on the nasal side of this spot is the *optic disc*, from the centre of which spring the retinal arteries and veins. The nervous or internal portion of the retina is transparent in health, but soon after death, removal of the eye, or detachment of the retina, it becomes opaque white.

The main blood supply of the retina is from the central artery, which is a terminal artery, and has no anastomotic communications on the retina; owing to this fact, stoppage of the blood through it, as by an embolus, produces complete blindness. A cilio-retinal artery from one of the posterior ciliary may supply a small portion of the retina, but cannot in any way take the place of the central artery as far as nutrition is concerned. The blood from the capillaries of the central artery returns by the radicles and trunk of the central retinal vein. The vessels are situated in the nerve fibre layer, and are surrounded by lymphatic sheaths, constituting the lymphatics of the retina.

The retina is the highly organised membrane forming

molecular; (4) *internal nuclear*; (5) *external molecular*; (6) *external nuclear*; (7) *rods and cones*. The connective tissue layers consist of the fibres of Müller, forming on the inner side of the nerve fibre layer the internal limiting membrane, and, between the rods and cones and the external nuclear layer, the external limiting membrane.

The yellow spot area differs from the rest of the retina histologically in an entire absence of rods at the fovea, where cones are alone present, and in Müller's fibres being arranged obliquely instead of vertically from within outwards.

The optic disc, consisting only of the fibres of the optic nerve, has no retinal nerve elements, and hence no power of sight (blind spot).

the end organ of the optic nerve, by means of which light is transmitted to the brain. If the retina be destroyed or removed the sense of sight is lost. The most important part of the retina for vision is the rod and cone layer, and here the visual sensations produced by light falling on the retina are transformed into waves which are conducted by the other nerve elements of the retina and by the optic nerve to the brain.

The optic disc area, as before said, is blind, and this fact must be remembered in mapping out a field of vision, as a scotoma will be found on the temporal side of, and a little below, the fixation point.

The yellow spot area is the only part of the retina capable of absolutely distinct vision. It is known as the *region of distinct vision*, and objects falling on other parts of the retina become more indistinct the farther they are from the yellow spot. At the fovea the elements of the retina excited by light must be at least 3 μ apart in order that two sensations excited at the same time may be distinct, this being the distance between the centres of two cones, and the fact can also be expressed by saying that two objects are not seen distinctly unless subtending an angle of sixty seconds or more.

It must be borne in mind that in viewing objects the image on the retina is always inverted like a photographic camera. The upper part of the retina is used for seeing objects in the lower part of the field of vision, the temporal portion for the nasal, and so on.

In binocular vision certain portions of the retina are associated (*corresponding parts*). Thus the upper portions of the retina work together, and also the lower, but the nasal side of the retina in one eye corresponds with the temporal side of the other, and *vice versâ*.

Congenital variations.—The retinal *vessels*, though generally arranged as described on p. 26, may vary greatly in distribution and appearance; sometimes they

M 2

may be extremely tortuous and difficult to diagnose from those seen in swelling of the retina, as in optic neuritis, but the tortuous parts of the vessels are always in the same plane.

Opaque nerve fibres (fig. 42).—Occasionally the optic nerve fibres of the retina retain their medullated nerve sheath, and this condition is recognised by the ophthalmoscope as bundles of brilliant white fibres, feathery towards the periphery. They are generally situated close

FIG. 42.—OPAQUE NERVE FIBRES

to and radiate from the optic disc, the details of which in some cases may be with difficulty made out, the only part not affected being the physiological cup. The retinal vessels are usually covered in places by the opaque nerve fibres. Vision is not perceptibly diminished, but the area of the blind spot may be increased.

Pigment.—This may be distributed between the blood-vessels like fine dust, and sometimes[1] black, well-defined spots may be seen. In all these cases the regularity of

[1] Stephenson, *Trans. Ophth. Soc.* vol. xi. p. 77.

the pigment and the absence of signs of old inflammation aid the diagnosis.

White spots and dots [1] may be found distributed over the retina and are, as a rule, discrete and well defined.

White or grey gauze-like *patches* may be present over the vessels, especially near the disc.

Vascular changes.—Hyperæmia and anæmia of the retina are often described, but it is very difficult except in extreme cases to make the diagnosis, as slight changes would be shown in the capillaries rather than in the larger vessels; venous engorgement is more frequently seen than dilatation of the arteries.

In cases of general anæmia, the fundus may be very pale and the arteries small. In cholera, the arteries are much constricted and nearly bloodless; this condition, known as *ischæmia*, is best seen in cases where very large doses of quinine have been given. In these cases of *quinine blindness*, extreme constriction of the arteries produces extensive contraction of the field of vision, and great loss of sight, attended by pallor of the optic disc. Complete recovery of vision sometimes takes place, but the arteries remain somewhat contracted, as does also the field of vision.

Pulsation of the vessels.—As before stated, venous pulsation or throbbing is very commonly seen, but is not necessarily a sign of disease. Arterial pulsation travels like a wave along the whole vessel, which apparently flushes, becomes empty, and then flushes again. It is found in aortic regurgitation, and also in glaucoma, when it is due to mechanical pressure.

Aneurismal dilatations of the arteries are occasionally seen.

Occlusion of the central artery, generally known as *embolism* of the central artery of the retina, causes total

[1] Gunn, *Trans. Ophth. Soc.* vol. iii. p. 110.

and instantaneous blindness of the eye unaccompanied by pain. The suddenness of the occurrence is often well shown by the patient stating to a minute the exact time of the attack; the blindness is almost always permanent, and the left eye is the one usually affected.

The ophthalmoscopic *signs* are very characteristic. The whole fundus is pale and hazy; the retinal arteries are small, especially near the disc, containing but little blood, which may appear to be broken into small bead-like columns. The absence of circulation of the blood is shown from the fact that pressure on the eyeball does not produce arterial pulsation, as it does in the normal eye. The retinal veins are narrowed, and the disc may be normal or pale. Sometimes within a few hours, at all events the next day, the retina becomes greyish white, in contrast to the yellow spot region, which stands out a vivid red colour (*cherry red spot*). This appearance is due to the choroid shining through the thinnest part of the retina. Small hæmorrhages may be found scattered about the fundus. After about a month the haziness clears off and is followed by atrophy of the disc and retina; the arteries appear as white threads, and there are generally superficial changes at the yellow spot. Occasionally blocking of a single branch occurs, in which case the loss of vision will be limited to the area supplied by this branch.

The symptoms were originally supposed to be due to an embolus, but a thrombus is probably the most common cause. Frequently no signs of disease can be found elsewhere to account for the plugging of the artery, but cases have occurred in endocarditis, atheroma, pregnancy, nephritis, and thrombosis of the veins of the leg.

Pathology.—In a few cases a definite plug has been found in the vessel; the haze of the retina is due to œdema of the nerve fibre layer.

A thrombus may be diagnosed sometimes by the

symptoms being less sudden and complete, and the history of previous attacks of transitory blindness.

Prognosis is bad as far as sight is concerned, which usually is reduced to perception of light, or at most of large objects.

Treatment is generally of no avail, though immediate massage has apparently done good in a few cases, as has also nitrate of amyl.

Thrombosis of the central vein may be complete or partial, and is followed generally by sudden loss of vision. Numerous and large hæmorrhages cover the fundus, and the retinal veins are enormously engorged and tortuous; the arteries are very small, but pulsation can be seen in them on making pressure on the eyeball. The condition generally results in atrophy of the retina and optic disc. It is met with in old people with atheromatous arteries, and sometimes follows cellulitis of the orbit.

Retinal hæmorrhages are a frequent sign of retinitis, but they often occur without any active inflammation.

They differ in shape according to position, and vary in colour from bright red to black. The *deep* hæmorrhages are round, oval, or irregular in shape, and generally small, though they may become confluent; they are found in any of the layers of the retina beneath the nerve fibres.

Extensive hæmorrhages beneath the retina occur occasionally after operations for glaucoma or even cataract, and generally destroy the sight; they result from rupture of a vessel, owing to the sudden diminution of intra-ocular tension.

The *superficial* hæmorrhages are in the nerve fibre layer, and follow more or less the radiating direction of these fibres; they tend to become linear and feathery towards their peripheral edge, and are often described as flame-shaped (Plate I. *b*).

A form of hæmorrhage occurring in the macular region is at first completely circular, and several times larger than the area of the yellow spot; it is situated in front of the retina, between it and the hyaloid membrane (*sub-hyaloid hæmorrhage*). During absorption of the blood it frequently appears as a semicircle with a straight border (fig. 43).

Hæmorrhages tend to absorb slowly, and if small, no trace may be left, but as a rule white spots, or patches, and black pigment are found in their site.

FIG. 43.—SUB-HYALOID HÆMORRHAGE

Vision is much interfered with if the hæmorrhage is in the yellow spot region, and when situated elsewhere a definite scotoma may result; in some cases the patient complains of seeing everything in a red haze.

They often follow injuries of the eye, especially when produced by a blunt instrument, but may occur idiopathically in old people, anæmic adults (especially females suffering from menstrual troubles and the menopause), and high myopia.

RETINITIS, or inflammation of the retina, is, as a rule,

bilateral, acute or subacute, and not accompanied by external signs.

The symptoms consist of diminution of acuteness of vision, especially in the dusk or at night, giving rise to night-blindness; fogginess of vision, everything being seen in a grey or yellow haze; limitation of the field of vision and scotomata; diminution of the light sense; alteration in the shape of objects, straight lines appearing bulged or waved (*metamorphopsia*, μεταμόρφωσις, change; ὁράω, I see), or objects appearing smaller than they really are (*micropsia*, μικρός, small; ὁράω, I see). There is often a feeling of discomfort in the eyes, but very rarely actual pain or photophobia.

The *signs* are chiefly ophthalmoscopic. In recent and acute cases there is want of transparency of the retinal details, which are seen in a dull smoky haze; the retinal vessels dilated and tortuous may be obscured by exudation and their visible number increased; hæmorrhages of various shapes appear, generally small, round or in patches, and sometimes flame-shaped; discrete or grouped spots and patches (plaques) of different size, varying in colour from white to yellow, may also be seen. These spots, mostly soft and woolly looking, except in the macular region where they are dead white, are generally found along and beneath the retinal vessels; the disc is congested with its edges indistinct, and patches of effusion are found along the vessels in its neighbourhood (*papillo-retinitis*).

In the late or degenerative stage there is atrophy of the pigment layer of the retina, rendering visible the choroidal vessels. The retinal arteries are diminished in size, and accompanied by white lines; the hæmorrhages are few and small, having been replaced by white bright patches containing cholesterine or by black pigment; the soft patches have disappeared, leaving sometimes minute sparkling dots or hard-looking opaque white

patches which are most persistent in the region of the yellow spot; the disc often shows signs of old papillitis.

Complications.—The choroid is generally implicated, and in acute retinitis there are always vitreous opacities.

Pathology.—The white spots or plaques may be due to varicose swellings of the nerve cells, exudation cells derived from leucocytes or the nuclear layers, fibrin between the nerve fibres, or fat globules. The opaque white spots are changes in Müller's fibres, and the sparkling dots are cholesterine.

Diagnosis.—The white spots or plaques are distinguished from patches of recent choroiditis by their more superficial position, and also from their softer appearance; from old choroiditis, by not being fringed with pigment.

The local *treatment* is the same for all varieties, and is mainly directed to procure rest for the eyes, especially from reading and near work, and avoidance of bright light and glare. The constant use of tinted glasses should be advised, those of the shade known as peacock blue being the best. Great care must be taken in the general treatment according to the diathesis of the patient.

Varieties.—Retinitis may be divided into certain clinical varieties.

Sclerosis of the retina (*Retinitis pigmentosa, pigmentary retinitis*) (Plate II. *b*) is the most chronic form of retinitis, and affects both eyes.

The ophthalmoscopic *signs* consist of a lacework of black retinal pigment near the equator and periphery, arranged as large branched cells resembling bone or corneal corpuscles seen under a microscope; owing to the absence of the pigment layer of the retina in places, the choroidal vessels are plainly visible as a network of light vermilion colour.

The retinal arteries, small in calibre, may be reduced to mere threads, and covered in places by the new pig-

ment. The optic disc is atrophied, pinkish grey in colour, with a peculiar waxy look. The *symptoms* are night blindness, concentric contraction of the fields of vision, and progressive loss of sight, ending after many years in complete blindness. The central vision may in some cases be normal, and yet the patient cannot find his way about in the streets, owing to the small size of the visual field. In some cases all the symptoms and signs are present with scarcely any pigment.

Complications.—Posterior polar cataract and disease of the vitreous may be present, and some of the patients are undersized and defective in intelligence. The exciting causes of the disease are unknown, but it commences in childhood or about puberty; it is hereditary, and frequently associated with a history of consanguinity.

Pathologically, there are signs of chronic inflammation of the retina marked by the presence of new pigment, especially along the vessels. There is sclerosis of the connective tissue with disappearance of the nerve elements, and thickening of the walls of the blood vessels, producing great diminution in their calibre.

The disease may be *diagonised* from syphilitic choroido-retinitis by the absence of limited patches of deep choroidal atrophy, and the more regular appearance of the changes. *Treatment* is of no avail, though the constant current is said to enlarge the field of vision for a time. Patients almost invariably become blind, but not for some years.

Albuminuric retinitis (Plate I. *b*) is the name given to a group of cases generally affecting both eyes, and as a rule associated with Bright's disease, though the same appearances may be present in cases of cerebral mischief and in others for which no definite cause can be found. The most distinctive *signs* are white spots and plaques situated in the deeper layers of the retina beneath and in the neighbourhood of the blood-vessels, especially

about the disc and the yellow spot. At the yellow spot they assume a star-like form, composed of numerous small concentric opaque white spots radiating in lines; this appearance is owing to the anatomical arrangement of Müller's fibres. The hæmorrhages are generally deep, small, and round or oval, though flame-shaped superficial ones may be present; the papilla is often swollen, and the retina round it œdematous; at the periphery a few scattered black pigment cells may be seen.

The disturbance of vision depends to a great extent on the position of the deposits, and it is surprising to find how little the sight is affected sometimes, considering the extensive changes present. The field of vision and colour vision are, as a rule, good.

Course.—Very little alteration takes place in the signs except that fresh spots and hæmorrhages continue to appear and disappear. The older spots lose their soft look, becoming more deeply situated, and, owing to fatty degeneration, denser white. When the acute inflammatory changes have passed off, atrophy of the retina and sometimes of the optic disc takes place.

The *complications* are papillitis, vitreous opacities, and detachment of the retina.

Causation.—The albuminuric cases are mostly met with in chronic interstitial nephritis, but also in chronic parenchymatous nephritis and lardaceous disease of the kidneys.

Pathology.—In those cases associated with chronic nephritis, there is an occlusive arteritis in which the intima is especially affected and the arterial coats much thickened; fatty degeneration is found in the nerve fibres and the fibres of Müller.

Prognosis.—In renal disease the appearance of retinitis is a late symptom, and with regard to life it is of the gravest import. The duration of life after its appearance is generally from nine months to two years.

The vision may be little affected even in the late stages, and if there is great loss of sight, it is usually due to uræmic amblyopia.

Occasionally, but very rarely, the retinal signs nearly disappear with the exception of slight changes at the yellow spot.

Gravidic retinitis is a form of albuminuric retinitis occurring during pregnancy, but chiefly differs from it in the symptoms tending to clear up after delivery, and in the prognosis being much more favourable to life.

Its onset is sudden, and accompanied by headache and flashes of light; the signs tend to increase and continue till the birth of the child. Vision may be reduced to perception of light, and remain permanently lost, or recovery may take place. The disease usually is met with during the later months of pregnancy, but if it occurs in the early stages, the prognosis is more unfavourable. The signs are sometimes the precursors of convulsions, and if increasing rapidly require the premature induction of labour. It is liable to occur again in a subsequent pregnancy.

Diabetic retinitis [1] is rare, and occurs in patients suffering from glycosuria. The ophthalmoscopic signs closely resemble albuminuric retinitis, but may sometimes be diagnosed from it by the more yellow colour of the plaques and also by the greater number and size of the retinal hæmorrhages. Cataract and vitreous hæmorrhages and opacities are frequently found.

The *prognosis* is not so rapidly fatal to life as in albuminuric cases.

Leukæmic retinitis [2] is characterised by the size and tortuosity of the retinal vessels, which have a peculiarly flattened look, and are disposed in bold curves. The colour of the fundus is pale red to orange yellow. The retina is œdematous, with numerous hæmorrhages and white or

[1] *Trans. Ophth. Soc.* vol. vi. p. 331, Plate II.

[2] *Ibid.* vol. vi. p. 345, Plate IV.

yellow spots surrounded by haze and most abundant at the periphery.

Retinitis circinata,[1] first described by Fuchs, occurs in old people, especially of the female sex, and is characterised by a circular arrangement around the disc of white patches and radiating lines, apparently situated in the deeper layers of the retina. Degenerative changes are usually present at the macula and retinal hæmorrhages occur. Vision is much reduced.

Syphilitic retinitis is generally associated with and as a rule secondary to choroiditis. It occurs in the secondary stage, and is met with in both the acquired and congenital disease. It commences as an œdema of the retina, the details of the fundus being seen in a grey haze. The disc looks hyperæmic, due to opacities in the vitreous, which are always to be found and generally very minute and dust like; retinal hæmorrhages are present especially along the vessels, which may appear thickened with white lines along them; black pigment patches, white spots and plaques may also be seen. Vision is affected to a variable extent, and night blindness and diminution of light sense are marked symptoms, as are also sensation of flashes of light, ringed or central scotomata, micropsia, and in the later stages, contraction of the field of vision. The progress of the disease is slow, relapses being very common; papillitis is often present, and pigmentary degeneration of the retina or disseminated choroiditis frequently supervene.

The prognosis in the early stages is good, if the constitutional *treatment* is well carried out by mercury, and afterwards by iodide of potassium.

Hæmorrhagic retinitis is generally monocular at commencement. The retina contains numbers of hæmorrhages mostly confined to the nerve fibre layer, and

[1] *Trans. Ophth. Soc.* vol. xiv. Plate III. fig. 2, and vol. xvi. Plate IV. & Plate V.

consequently flame-shaped; it may be œdematous with a few white plaques. Papillitis is often present, and the retinal veins are much distended and very tortuous. The signs resemble thrombosis of the retinal vein, and probably are often due to this affection. It occurs in gouty patients in middle or advanced age, and is associated with cardiac valvular disease, aneurism, hypertrophy of the left ventricle, atheroma, menstrual troubles, and hæmorrhoids.

Prognosis is unfavourable, and relapses are very common.

The *treatment* consists of rest for the eyes, dry cupping to the temple, and iodide of potassium with mercury internally.

Purulent retinitis is due to septic emboli in the retinal arteries; it occurs in septicæmia after operations, and also in cases of metritis. There are at first small white spots about the optic disc and the macular region, and numerous hæmorrhages with œdema of the retina. These signs are soon followed by suppuration along the uveal tract, ending in panophthalmitis and destruction of the eye.

Functional night blindness.—Besides the night blindness occurring in the different forms of retinitis, there are cases in which, with no ophthalmoscopic changes, this symptom occurs. The subjects are generally out of health and ill-nourished; on the Continent epidemics of the disease occur during prolonged fasts. It is met with in cases of scurvy; exposure to bright light or snow and sleeping in the moonlight are also exciting causes.

The cases under my own observation have been anæmic and ill-fed children in the spring and early summer; the only objective symptom has been the presence of small dry patches on the conjunctiva near the outer or inner border of the cornea covered with a frothy scum looking like small bubbles, and consisting of epithelial débris with

colonies of the bacillus of xerosis. All the symptoms disappear on improving the general health by tonics, as cod-liver oil and iron, and the use of dark glasses.

Torpor or anæsthesia of the retina from defective nutrition is the cause of the disease.

Retinal changes, due to bright light, are seen chiefly at the macula in cases of exposure of the eyes to the sun, as in watching an eclipse, or to the electric light.

The symptoms are diminution of vision, and an absolute central scotoma. The signs at the yellow spot are granular pigment changes, or a small atrophic patch with occasionally small hæmorrhages. As a rule, by resting the eyes and wearing dark glasses the vision recovers, though the scotoma generally remains.

Detachment of the retina has been described as a separation of the retina from the choroid by serum, blood, or a new growth, but it is best to limit the term to cases in which the pigment layer is separated from the rest of the retina by serous effusion.

The *symptoms* consist of loss of vision (the extent of which depends on the situation of the detachment), distortion of images, a floating cloud before the eye, and muscæ volitantes.

The *signs*.—Detachments may be either shallow or steep. The shallow variety may still possess the red choroidal reflex, and can in some cases only be recognised by the difference in the refraction of a blood vessel passing over it, from that of the rest of the retina.

The steep and most common form (fig. 44) is usually situated towards the periphery of the retina, and is said to commence most frequently above, but from the effect of gravity is generally seen below. It often requires complete dilatation of the pupil and careful examination of the periphery for its recognition, and is seen coming forwards into the vitreous as a white or blue-grey eminence thrown into folds, and aptly described as resembling

Alpine scenery. On and over these folds run the retinal vessels, altered to a dark red or even black colour, and lost to view in places. The rest of the fundus maintains its normal appearance, except that in the neighbourhood of the detachment there may be white lines in the retina, the result of stretching. In many cases rents in the detached retina may be found.

In the steep variety the detachment may be seen to wave about with quick movements of the eyeball, and the parallax can be obtained (page 25). The tension of

FIG. 44.—DETACHMENT OF RETINA

the eye is generally lowered, and the anterior chamber deepened. The field of vision shows as a rule a scotoma or limitation over the area corresponding to the detachment.

The *Causation* is either injury or disease. Traumatic separation generally follows direct blows on the eye without rupture of the eyeball, but may follow wounds of various kinds, including those of operation. Myopia and disease of the vitreous especially predispose to this condition.

Pathology.—The probability is that idiopathic detachment always takes place from pathological changes in the vitreous, either the result of shrinking or the presence of inflammatory products. The serous fluid beneath the detached retina corresponds nearly in composition to the vitreous fluid. The presence in so many cases of ruptures in the retina suggests that vitreous fluid may thus pass beneath the retina.

Between a serous detachment of the retina and a solid tumour, the diagnosis is often very difficult, but the detachment is more transparent looking, and often floats with the movements of the eyeball.

The *Prognosis* is generally bad, and in idiopathic cases the detachment tends to become general, as even after great improvement cases generally relapse.

Treatment is very unsatisfactory. In recent cases it is most important that the patient should have absolute rest in bed with the head kept low. The eyes should be protected with dark goggles. Subcutaneous injections of pilocarpine, in order to produce sweating and salivation, may be tried. Cauterisation of the sclerotic corresponding to the situation of the detachment has been recommended. Puncture of the sclerotic may be successful for a time, but in all the cases I have seen, secondary detachment has ensued, owing to cicatricial changes in the vitreous.

The *operation* is performed under cocaine. A speculum being introduced between the lids, the conjunctiva corresponding to the seat of detachment is divided with a pair of scissors, and the subconjunctival tissue dissected till the sclerotic is laid bare. A double-edged broad needle is passed through the sclerotic, the cut being made in a radiating, antero-posterior direction. Straw-coloured fluid is then evacuated, and it is advisable, in order to withdraw as much as possible, to separate the lips of the incision with a curette. The edges of the conjunctival

wound are then stitched together, and both eyes kept bandaged for four or five days.

TUMOURS OF THE RETINA.—**Glioma** [1] is a malignant tumour, probably a carcinoma, found in children mostly about two years of age, and may sometimes be congenital. It generally occurs in one eye, though in many cases (20 per cent.) both eyes are affected.

At first there are no *symptoms*, and this stage is known as the *non-irritative* period. By the ophthalmoscope, a small pinkish-white nodular, solid looking and immovable swelling, covered by the retina, is visible generally near the optic disc. The tumour may be seen by focal illumination or by the naked eye, and children are generally brought for advice by their parents on account of the appearance of this yellowish reflex. The tumour tends to grow into the vitreous, and retinal hæmorrhages may be seen on it. At this stage the intra-ocular tension is raised, giving rise to glaucomatous symptoms (*irritative stage*). It next tends to grow along the optic nerve towards the brain, and may burst through the sclerotic as a fungating mass (*extra-ocular stage*).

Pathology.—The tumour is very soft, and consists of small round non-pigmented cells imbedded in a semi-fluid cellular matrix, many of the cells show signs of degeneration.

Glioma may be mistaken for pseudo-glioma, or solitary tubercle of the choroid, as they all occur in children. The normal or increased intra-ocular tension, absence of iritis or of recent severe illness, distinguish it from pseudo-glioma; from tubercle of the choroid, the presence of tubercle elsewhere is the only means of diagnosis.

It may be distinguished from choroidal sarcoma by its greater malignancy and its tendency to occur only in young children, to become bilateral, to degenerate, and to

[1] Lawford and Collins. Notes on Glioma Retinæ. *Roy. Lond. Ophth. Hosp. Rep.* vol. xiii. p. 12.

affect the cranial bones and glands about the jaw, rather than the liver and internal organs.

If the eye be excised before the optic nerve becomes involved the prognosis may be good, but if extension of the disease along the nerve has taken place, a fatal result is imminent.

The *treatment* consists in excision of the eyeball, care being taken to cut the nerve as far back as possible. If both eyes are affected they should both be excised, as the patient's life may be thereby saved.

INJURIES.—The most common traumatic retinal change is detachment of the retina (p. 176). Rupture of the retina is probably always associated with rupture of the choroid and cannot with certainty be distinguished from it. In some cases following a severe blow on the eyeball there is considerable loss of sight and contraction of the visual field without any ophthalmoscopic change (*commotio retinæ*); in other cases hæmorrhages and œdema of the retina may be produced.

CHAPTER XIII

DISEASES OF THE OPTIC NERVE

Anatomy and physiology.—The optic nerves are really portions of the brain, and consist of medullated nerve fibres without neurilemma, bound together by neuroglia. The fibres are mostly of small diameter (2 μ), but a few are larger (5 μ to 10 μ). The main function of the nerve is to transmit visual sensations from the retina to the brain, though some fibres, probably the larger ones, are for the afferent path of the pupillary reflex.

The visual fibres of the nerve (fig. 45) are divided in their course into the macular fibres and those for the rest of the retina. The macular fibres (mf) for the supply of the yellow spot region are to be found in the middle of the nerve (axial fibres), except in the intra-orbital portion of the nerve near the eyeball, where the fibres change their position, forming a wedge-shaped mass at the temporal side of the nerve.

The optic nerves extend from the optic papillæ formed by the nerve fibres of the retina to the chiasma.

At the chiasma most of the fibres of both optic nerves enter the optic tracts, but at the posterior border of the chiasma a few pass to the floor of the third ventricle; these are probably the optico-pupillary fibres, passing to the portion of the nucleus of the third nerve, situated in the aqueduct of Sylvius, for the contraction of the pupillary muscle. The fibres of each tract communicate

with the anterior quadrigeminal body, the lateral geniculate body and the pulvinar, and are afterwards distributed to the occipital lobe (cuneus).

Though the optic is an afferent nerve, it is best to describe its course from the decussation at the chiasma

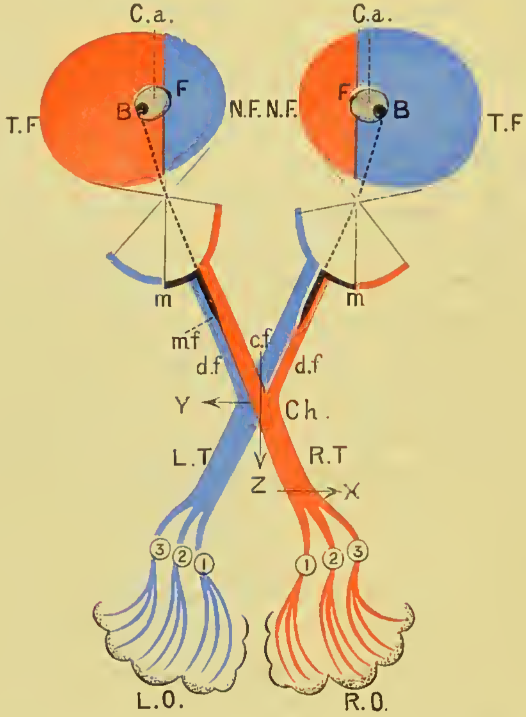


FIG. 45.—DIAGRAM SHOWING COURSE OF OPTIC NERVE FIBRES

R.O., L.O., occipital lobe (cuneus); 1, anterior corpus quadrigeminum; 2, corpus geniculatum lateral; 3, pulvinar; L.T., R.T., optic tract; Ch., chiasma; d.f., direct fibres, and c.f., crossed fibres of optic nerve; m.f., axial or macular fibres; m. yellow spot. In fields of vision N.F., nasal, and T.F., temporal fields; F., fixation point; B, blind spot (optic nerve area); C.a., central area of field corresponding to axial fibres; X, lesion of right tract producing left hemianopsia: Y, lesion of outer side of chiasma followed by left nasal hemianopsia; Z, lesion through chiasma producing bitemporal hemianopsia.

onwards to its distribution in the retina. It may be divided into three portions: *intra-cranial,* from the chiasma to the optic foramen in the sphenoid bone; *intra-orbital,* from the optic foramen to the sclerotic; and

intra-ocular, from the sclerotic foramen to its termination in the retina. The *intra-cranial* portion has only a pial sheath, and receives fibres at the chiasma from both optic tracts; the *direct* fibres (d. f) from the tract of the same side supply the retina to the temporal side of the yellow spot; and the *crossed* fibres (c. f.) from the opposite tract, which are the more numerous, supply the retina to the nasal side of the yellow spot.

The *intra-orbital* portion is enclosed in a sheath formed externally by dura mater and internally by pia mater; the dural sheath is very strong, and is continued as the sclerotic, whilst the pial sheath is much more delicate. Between these sheaths is the intervaginal space (fig. 46, i. v.) or lymph channel, continuous with the subarachnoid and subdural spaces; it is in this space that bacilli have been found in experiments on sympathetic inflammation. The nerve is much less rigid than in the first part, in order that it may not be affected by the movements of the eyeball. It is 28 mm. long, and is pierced 15 mm. from the scleral foramen by the central retinal artery and vein.

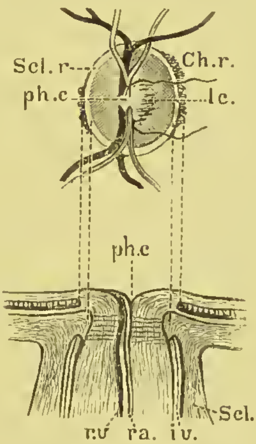


FIG. 46.—DIAGRAM OF INTRA-OCULAR PORTION OF OPTIC NERVE AND OPTIC DISC

ph. c, physiological cup; l. c., lamina cribrosa; Scl. r., scleral ring; Ch. r., choroidal ring; r. a., r. v., retinal artery and vein; i. v., intervaginal space.

The *intra-ocular* portion is the most important in ophthalmology, as its termination in the optic papilla can be investigated by the ophthalmoscope. The nerve (fig. 46) on its passage through the sclerotic foramen becomes smaller and funnel-shaped, and at the same time the nerve fibres, losing their medullated sheath, appear transparent, and are divided up by fine fibres (*cribriform*) (l. c.) derived

from the sclerotic. The nerve then passes through an opening in the choroid (Ch. r.) (*choroidal ring*), and, bending over, is distributed as the nerve fibres of the retina. This slightly raised convex mass of nerve fibres is the optic papilla or optic disc. From near the centre of this disc, and dividing it into two portions (nasal and temporal), emerge the central retinal vessels, the vein being usually on the nasal side. At the exit of the vessels is a slight depression known as the physiological cup (ph. c). The edge of the disc is marked by the scleral or connective tissue ring (Scl. r), and the choroidal ring (Ch. r) may also be seen in places as a pigmented border. The ophthalmoscopic appearances of the normal optic disc are described on page 24, and figured in Plate I. *a*.

Near the scleral foramen, the optic nerve is supplied by numerous small branches of the posterior ciliary arteries, forming the circle of Haller.

From physiological experiments and pathological investigation, the following facts have been deduced. Section of an optic nerve produces complete blindness of the eye on the same side, and also loss of direct pupillary light reflex.

Section of an optic tract is followed by complete blindness of the corresponding halves of the visual fields on the opposite side (homonymous hemianopsia). In fig. 45, section (X) of the right tract would produce blindness in the right halves of each retina, and the left halves of the visual fields (coloured red in diagram).

In some cases of homonymous hemianopsia the pupillary reflex has been found absent on throwing light on the blind halves of the retinæ. This result is very difficult to obtain, and points to the lesion being anterior to the corpora quadrigemina.

Destruction of a portion of a tract is followed by partial hemianopsia, the scotomata being in corresponding parts of the fields.

Antero-posterior vertical section (fig. 45, Z) through the middle of the chiasma divides the crossed fibres of both tracts, and produces bi-temporal hemianopsia.

A lesion involving the outer side of the chiasma (fig. 45, Y) would produce nasal hemianopsia of the eye on that side. Disease of the occipital lobe near the cuneus is followed by hemianopsia; this symptom is a psychical blindness, and the patient does not complain of a sensation of darkness in the blind portions of the field.

Congenital abnormalities.—*Coloboma of the disc* is of rare occurrence, and has been mistaken for posterior staphyloma. The disc is excavated below and its area increased; the condition is attended sometimes by coloboma of the choroid.

Congenital crescents situated below the disc are probably a species of coloboma, or may be due to an uneven distribution of the lamina cribrosa.[1]

The optic disc may vary greatly in *colour*, sometimes being red and congested-looking, and at other times as white as an atrophied disc. From these facts it is extremely difficult to diagnose *hyperæmia* or *anæmia* of the disc. It must be remembered that vitreous opacities and refraction errors may frequently render the disc hyperæmic-looking.

INFLAMMATIONS OF THE OPTIC NERVE.—The term *optic neuritis* is applied to all inflammations of the optic nerve. It is, however, best to divide optic neuritis clinically into two groups: *Papillitis*, characterised by visible changes in the papilla; and *Retro-ocular* neuritis, in which, with failure of vision, there are at first no visible signs of inflammation, as the nerve fibres are affected behind the eyeball. These latter cases have only of late years been removed from the ever diminishing list of 'amblyopias.'

[1] Frost, *The Fundus Oculi*, p. 78.

Papillitis (Plate III. *a*).—The earliest *signs* are congestion of the disc characterised by increased vascularity and redness, the edges becoming blurred or indistinct, and peculiarly striated. This (congestion stage) is often difficult to diagnose, as hypermetropic astigmatism may produce similar appearances. These slight signs are soon followed by more marked ones (neuritis stage), which render the diagnosis of papillitis certain. The disc becomes striated, swollen, and projecting; no trace of its margin can be discovered, the situation of the disc being indicated only by the convergence of the retinal blood-vessels. The swelling of the disc is recognised by the bending of the vessels, by the parallactic movement, and by the necessity of using convex glasses to focus the apex of the swelling. In extreme cases the swelling may be 2 to 3 mm. (6 to 9 dioptres) in height. The retinal vessels are curved forwards, tortuous, interrupted in places, and their point of entrance in the optic disc obscured; the arteries may be small or normal in calibre, the veins are distended and knotted. White plaques and flame-shaped hæmorrhages occur along, and sometimes obscure, the vessels on or near the disc. The neighbouring part of the retina is usually swollen, œdematous, with hæmorrhages and white exudation patches on it.

Symptoms.—Acuity of vision, colour vision, and field of vision may be normal or impaired, and this depends on the coarseness of the lesion. As a rule the field of vision is limited peripherally, and colour vision is defective, even when the acuity of vision is normal. Scotomata in the form of patches or rings may exist. Photophobia and pain in the eye are rare.

The *course* may be very rapid, or chronic. The papillitis may disappear in two or three weeks. As a rule, atrophy (Plate III. *b*) (post-papillitic) results, and is shown by whiteness of the disc, the margin of which becomes irregular and surrounded by changes in the

PL. III.

a

PAPILLITIS.

b

POST-PAPILLITIC ATROPHY.

choroidal ring; the lamina cribrosa is generally ill-defined, and the physiological cup filled up; the retinal vessels become diminished in size, and have white lines along them.

Causation.—Papillitis is as a rule bilateral; if unilateral, it is probably due to orbital disease. It is important to note that frequently the changes in one eye precede those in the other, and in cases due to intracranial mischief, any operative procedure should be undertaken on the side on which the neuritis first appears.

The *causes* of papillitis are numerous, and may be classified as follows: *Diseases of the nervous system*: (1) *Brain*: Tumour (syphilitic, tubercular, glioma), abscess, cysts, aneurism, meningitis (simple, tubercular and cerebro-spinal), hydrocephalus and cerebral hæmorrhage. (2) *Spinal cord*: myelitis and disseminated sclerosis. (3) *Nerves*: peripheral neuritis. *General diseases*: chlorosis, anæmia, amenorrhœa, syphilis, rheumatism, fevers (measles, scarlatina, influenza, &c.), albuminuria, and diabetes. *Poisons*, as lead. It may also be produced by cold.

Local diseases.—Ocular: sympathetic ophthalmitis; *orbital*: tumour and inflammatory affections as caries and cellulitis.

In general, it may be stated that cerebral tumour and tubercular meningitis are the most frequent causes, though in many cases no cause whatever can be discovered, and there seems to be a hereditary predisposition to papillitis just as there is to optic atrophy. Syphilis causes papillitis in various ways: (1) as a tumour in the brain, or optic tract; (2) as a simple neuritis ending in atrophy; (3) as a meningitis. In albuminuria it is always complicated by retinitis. Some rare cases of papillitis have been described, associated with a dripping of clear fluid from the nose and attended by certain cerebral symptoms.

Pathology.—In the *congestion* stage there is distension

of the vessels, with infiltration of serum and dilatation of the intervaginal space.

In the *neuritis* stage, besides the great venous engorgement, the optic disc is swollen, infiltrated with small lymph cells and leucocytes, and generally has hæmorrhages upon it; the thickened nerve fibres are varicose, and show signs of fatty degeneration; the retina at the edge of the disc is œdematous, and its nerve-fibre layer thickened; the intervaginal space is always markedly dilated, and filled with fluid.

The exact cause of the occurrence of papillitis in cases of cerebral tumour is still a matter of much uncertainty.[1] The old idea that it is due to the obstruction of the retinal vessels is untenable, as is also the theory that it may be caused by increase in intra-cranial pressure from the tumour. A very small tumour may excite the most intense papillitis. It has been suggested that the tumour may act as a foreign body,[2] and induce reflexly changes in the vaso-motor nerves.[3] Distension of the nerve sheath by fluid is a nearly constant accompaniment of the papillitis, and this fluid probably contains sources of irritation[4] either chemical or bacterial.[5] There are many reasons for thinking that the direct cause is meningitis,[6] spreading from the membranes of the brain along the sheath of the nerve.

Diagnosis.—It is often difficult and sometimes even impossible to say by ophthalmoscopic appearances whether

[1] The student is advised to read the masterly description of papillitis in Gower's *Medical Ophthalmoscopy*, third edition, 1890.

[2] Hughlings Jackson, *Roy. Lond. Ophth. Hosp. Reports*, vol. iv. p. 12.

[3] Benedict, *Allg. Wien. Med. Zeit.*, 1868, No. 3.

[4] Leber, *Trans. Internat. Med. Congress*, London, 1881, vol. iii. p. 52.

[5] Deutschmann, 'Ueber Neuritis Optica,' Jena, 1887, *Ophth. Rev.* vol. vi. p. 107.

[6] Edmunds and Lawford, *Trans. Ophth. Society*, iii. p. 139, and iv. p. 172.

slight papillitis is present or not, and it is only after a long experience with the ophthalmoscope that the various appearances of the optic disc in health and disease can be fully and truly appreciated. Owing to this fact, records of slight neuritis must be accepted with caution. Hypermetropic astigmatism gives rise to a distorted appearance of the disc which might easily be mistaken for early papillitis.

The *prognosis* in most cases is that complete or partial atrophy ensues, but occasionally in syphilitic cases perfect recovery has occurred. The fields of vision generally remain contracted or altered, even when the acuity of vision is normal. Occasionally a second attack of papillitis occurs in the same eye.

The *treatment* is mainly constitutional according to the diathesis of the patient. In syphilitic cases mercury must be given actively and persevered with, and it may be prescribed with good results in most other cases except anæmia, when iron is specially indicated. The eyes should be shaded as much as possible by tinted glasses or goggles, and the patient at first kept at rest in bed.

In cerebral cases trephining the skull occasionally relieves the symptoms, and when uniocular the nerve sheath has been opened with good result.

Retro-ocular neuritis.[1]—The chief characteristics are impairment and even complete loss of vision for near and far objects ; at first, and sometimes during the whole attack, absence of ophthalmoscopic signs ; the presence of a central scotoma (fig. 47)—generally relative and for red and green.

The cases may be divided clinically into two classes : (1) *Acute*, as a rule unilateral ; and (2) *Chronic*, nearly always bilateral, and of toxic origin.

(1) **Acute retro-ocular neuritis.**—The *symptoms* are a feeling of stiffness and discomfort about the lids

[1] Nettleship, *Trans. Ophth. Soc.* vol. iv. p. 186 ; 'Discussion on Retro-ocular Neuritis,' *Trans. Ophth. Soc.* vol. xvii. pp. 107–217.

and eyes; pain on extreme lateral movements of the eye, especially outwards to the temporal side, due to stretching of the inflamed optic nerve; the pain, which is the first symptom, lasts a few days.

There is usually neuralgia on the same side of the head, and pain and tenderness on pressing the eye backwards into the orbit. Vision is impaired, and may be absolutely lost; it is always worse in bright light and after physical exhaustion. Even when visual acuteness is good there is slowness in reading the test types, which

FIG. 47.—VISUAL FIELD IN A CASE OF CHRONIC RETRO-OCULAR NEURITIS (TOBACCO), SHOWING THE CENTRAL SCOTOMA FOR RED AND GREEN SHADED, AND A NORMAL FIELD FOR WHITE

occasionally appear to the patient to move. There is an appearance as of a gauze or crape veil before the eyes, and objects such as straight lines look broken.

Signs.—With the ophthalmoscope, nothing abnormal can be seen at first, but sometimes there is a slight haziness about the disc, which is whiter than usual at the temporal side. The pupil on the same side is generally

inactive to light, or the action is not maintained on continued exposure.

The failure of vision may increase for two or three days and then remain stationary. Cases which recover generally take from four to six weeks.

Complications.—The sixth and other cranial nerves may be involved. Atrophy of the optic nerve often follows, the pallor usually setting in from two to four weeks after the onset.

Causation may be orbital periostitis (syphilitic, tubercular, or traumatic), rheumatism, gout, malaria, and exposure to cold. It also follows injuries, such as fracture about the optic foramen.

The *treatment* consists of mercury and iodide of potassium, with blisters, and dark glasses.

(2) **Chronic retro-ocular neuritis** (*toxic amblyopia*) comprises a group of cases which in England have been attributed to tobacco, but similar symptoms have also been found associated with alcohol, bisulphide of carbon, lead, diabetes, and disseminated sclerosis. Both eyes are affected as a rule, but occasionally only one.

The *symptoms* are diminution of vision for far and near objects, especially in bright light, and patients complain of seeing everything in a grey or yellow fog, and of want of ability to distinguish between gold and silver coins.

The periphery of the field of vision is normal, but a relative central scotoma is present for red and green, and in some cases the scotoma is absolute (see p. 33). The scotoma is generally small and situated within the 10° circle (fig. 47), but sometimes occupies nearly all the red field. The scotoma is best found by means of a red square, as described at p. 36, and will be found at the fixation point and slightly to its outer side, as this part of the field corresponds to the area of distribution of the axial fibres of the optic nerve (fig. 45).

Ophthalmoscopically, no marked changes are found in

most cases in the disc or vessels, but occasionally the former appears whiter than normal at the temporal side, and a few cases have been described in which papillitis and atrophy were present.

Course.—If the toxic material be not withheld, the vision tends to become more defective and the central scotoma more marked. In severe cases vision may be reduced to $\frac{1}{60}$, but rarely less. Improvement, as a rule, follows when the cause is removed, and vision may be completely restored. There is a class of cases in which the vision has been much deteriorated, and in which improvement does not take place.

Causation.—So far as tobacco is concerned, shag, cavendish, and strong cigars are the most liable to produce the disease. It may follow smoking. chewing, and snuff-taking. Some constitutions are especially prone to it, and I have known one case in which a non-smoker developed severe symptoms after using snuff for a cold for only ten days. There is little doubt that in most cases the general health is undermined before the toxic effects appear; thus very often such exciting causes as mental or bodily strain, starvation, or excessive venery are to be found. I have never met with a case in which alcohol or diabetes has produced the disease in a non-smoker.

Pathologically, there is a neuritis of the axial fibres of the optic nerve.

The *treatment* is primarily to leave off the use of tobacco in any form, and to take as little alcohol as possible, and that only with meals. Strychnine should be given either hypodermically or by the mouth in increasing doses, and the general health must be carefully studied.

Atrophy of the optic nerve may be found as a primary disease (*primary atrophy*), or secondary to some other affection of the nerve or retina (*secondary atrophy*).

The chief *symptoms* are connected with impairment of vision—namely, diminution of vision for far and near ob-

jects; concentric or irregular limitation of the visual field; central, ring or multiple scotomata; colour-blindness—green being lost first and then red; loss of light sense.

The *signs* vary greatly. The disc is always altered in colour, being dead white like chalk or blanc-mange, but it may be grey or white tinged with blue or green; in appearance it is opaque or waxy-looking, with loss of the usual physiological cupping; in size it seems diminished; the lamina cribrosa may be more visible than in health; the scleral ring is often very distinct, and the whole disc is slightly cupped, having the form of a shallow saucer (fig. 10, B).

The condition of the vessels may appear normal, but the arteries are generally reduced in calibre.

It must be strongly impressed on the student that atrophy cannot be diagnosed from ophthalmoscopic signs alone, as some discs present congenital appearances like atrophy, and in old age the papilla often looks grey. The tendency in atrophy is for the symptoms and signs to increase, and, as a rule, to end in absolute blindness.

Primary atrophy, often called *progressive atrophy*, occurs occasionally without any apparent cause; it may be congenital, and in some cases heredity[1] can be traced. The most common association is with locomotor ataxy, but it may be found in general paralysis of the insane, disseminated sclerosis, acromegaly, and as the result of syphilis, alcohol, tobacco, and lead.

In these cases, the disc is frequently paper-white, with the edges sharply defined and regular; in the early stages, the colour may be scarcely altered. The fields of vision exhibit marked concentric contraction.

Secondary atrophy follows papillitis, retro-ocular neuritis, embolism of the central artery of the retina, retinitis especially pigmentary and glaucoma.

In post-papillitic atrophy (Plate III. *b*) the disc has

[1] Habershon, 'Hereditary Optic Atrophy,' *Trans. Ophth. Soc.* viii. p. 190.

a filled-up appearance, and its edges are irregular and badly defined. The vessels, generally tortuous, have white lines along them near the disc, may be obscured in parts and curved antero-posteriorly from the effects of the swelling of the disc.

After embolism the arteries are reduced to white lines. In retinitis pigmentosa the disc has a waxy appearance.

Pathology.—In primary atrophy the condition is due to a sclerosis of the connective tissue of the optic nerve, and, as a rule, originates at the papilla. In secondary atrophy the changes are generally the result of pressure on the nerve fibres from the products of inflammation.

The *treatment* in cases with syphilitic history is by mercury and iodide of potassium. In progressive atrophy, hypodermic injections of strychnine or galvanism may sometimes retard the progress.

Tumours of the optic nerve are very rare, and include myxoma, glioma, fibroma, and neuroma.

The *symptoms* are proptosis of the eyeball and great defect of sight. Papillitis or optic atrophy is generally present. The extra-ocular muscles not being involved, the movements of the eyeball are at first normal. Occasionally the tumour can be felt by the finger. The *treatment* is removal of the tumour, together with the eyeball.

The optic nerve may be implicated and its functions interfered with or even destroyed, by intra-cranial tumours (pituitary body, &c.), aneurism of the internal carotid or ophthalmic arteries, caries of the sphenoid, orbital abscess, gumma or tubercular deposit, and by meningitis.

Injuries of the optic nerve are generally the result of stabs, blows, or shot-wounds; they may follow falls on the head with or without fracture of the base of the skull. The optic nerve may be divided or only injured, and in some cases hæmorrhage may occur in the nerve sheath. As a rule, the signs and symptoms are those of acute retro-ocular neuritis, and descending atrophy of the optic nerve occurs after fourteen days.

CHAPTER XIV

AMBLYOPIA

AMBLYOPIA (ἀμβλυς, obtuse) is the term used for those cases in which the visual acuity remains below normal, even when an error of refraction has been corrected by glasses, though by the ophthalmoscope no signs can be seen to account for the loss of vision. It may vary greatly in amount, and if the eye is absolutely blind, the term *amaurosis* (ἀμαυρὸς, obscure) is employed.

Congenital amblyopia is, as a rule, uniocular, but may affect both eyes. If the defect exists only in one eye the patient generally has, or has previously had, a squint in that eye. It is not at all unusual even for an adult to be ignorant of the loss of vision, especially if the left eye is the one affected.

In binocular cases, the amblyopia is frequently associated with high degrees of hypermetropia, myopia, or astigmatism ; these refraction errors have prevented clear images from being focussed on the retina, and in this way probably have caused the amblyopia. In these cases, correction of the refraction does not bring the vision up to normal, but correcting glasses may after a time improve the visual acuity obtained at first by their use.

Congenital amblyopia does not tend to become worse, and very rarely improves in any appreciable degree except in refraction cases after the use of suitable glasses. The fields of vision and colour vision are usually normal. Amblyopia has been described as following disuse of an

eye, with constant suppression of the image formed, chiefly in cases of strabismus. This is exceedingly doubtful, as in cases of long-standing strabismus the vision sometimes is normal in either eye.

Reflex amblyopia has been described in one or both eyes following irritation of a nerve; in most cases the exciting cause has been a tooth, generally a molar, and sight has returned on removal of the tooth.

Uræmic amblyopia is found in cases of nephritis, due to scarlet fever or pregnancy, and is frequently associated with convulsions. The failure of vision is quite sudden, the patient waking up blind; the pupil is generally dilated but reacts to light. The blindness lasts two to three days, and the sight may be completely regained. A similar condition is found occasionally in diabetes.

Hysterical amblyopia is associated with other signs of hysteria, especially hemianæsthesia and aphonia. Patients often complain of photophobia and the appearance of flashes of light and colours; there may be blepharospasm, watering of the eye, spasm or paresis of accommodation. It is nearly always unilateral, but occasionally bilateral. The blindness may be partial or absolute.

The fields of vision are concentrically contracted, and in many cases a curious condition of spiral fields (fig. 48) may be obtained by the perimeter; spiral fields are apparently due to the retina being tired by exposure, and are obtained by continuing to take the field again and again on the same chart at the same sitting; each successive tracing is smaller than the preceding one, and at last the fixation point may be reached. Colour-blindness is sometimes present, and also micropsia and uniocular diplopia. The pupillary reflexes are normal, and there may be anæsthesia of the conjunctiva and cornea. It is usually found in young females, and is rare in males; it may last for months.

Simulated amblyopia (malingering).—Cases occur from time to time of patients feigning loss of vision in order to obtain immunity from work such as military service, or compensation for injury. It is not an uncommon occurrence in hysterical and nervous subjects and in children. The usual symptom is loss of sight in one eye, but sometimes in both. In some cases it is very difficult to determine the truth of the statements, but one or more of the following tests generally detects the imposition. It may

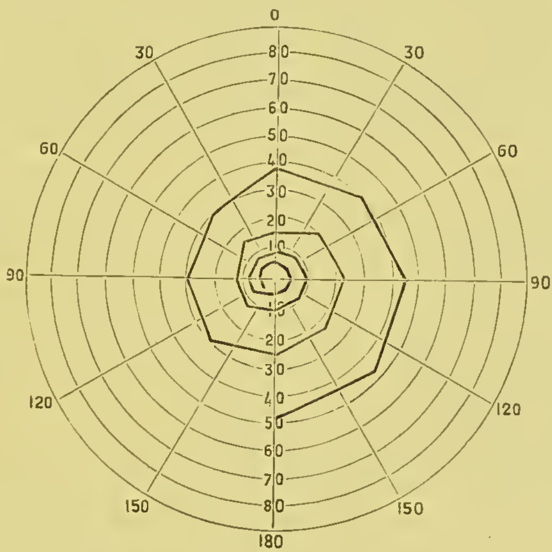


Fig. 48.—Spiral Visual Field

be said generally that a blind person, unless suffering from ataxia, has a certain confidence in his movements, holds his head erect and generally thrown backwards. Methods of detecting malingering if confined to one eye :

1. Hold a prism, with base downwards, in front of the good eye, and diplopia will be produced with the images one above the other if the vision is good in both eyes.

2. With the good eye covered up tell the patient to look at his own hand held in front of his face, and, if really

blind, he will look towards his hand, but if malingering, he will probably look in another direction.

3. If with atropine in the sound eye, and its accommodation thereby paralysed, the patient with both eyes open can read small print, the other eye is—unless the patient is very myopic—not 'blind.'

4. Test with glasses of different strengths, and see if the patient's answers are consistent.

5. Cover up the 'blind' eye, and then cause monocular diplopia (one image above the other) in the good eye, by means of a prism whose apex crosses the centre of the pupil. Now at the same moment uncover the 'blind' eye and move the prism so as to entirely cover the pupil. A malingerer will still see double images (binocular diplopia).

6. Snellen's method is to take a pane of glass with transparent coloured letters on it, alternately red and green. The patient wears a spectacle frame with a red glass in one eye (in this case the 'blind' eye) and a green in the other, and looks at the illuminated type; if he reads all the letters he can see with both eyes, but if the eye is really blind he cannot see the red letters.

7. Place in a trial frame a + 14 D. lens in front of the good eye, and a − ·25 D. or + ·25 D. before the 'blind' eye. A malingerer will often read the distant test types believing that there is the same strength of lens in front of each eye. On now excluding the 'blind' eye he will be unable to read the distant type.

8. Ask the patient to read the near type, whilst a pencil is held in front of the good eye, as in testing for binocular vision. If he can do so and words are not blocked out, it proves that he has binocular vision, and is using his 'blind' eye.

Hemianopsia (ἥμισυς, half; ανα, not; ὁραω, I see), or loss of half the visual field, is, as a rule, binocular, and due to disease or injury of the chiasma, optic tract,

or its cerebral communications. Uniocular hemianopsia is caused by disease of the chiasma or the retina (detachment, &c.). Binocular hemianopsia is generally homonymous, but may be temporal or altitudinal.

Temporal, altitudinal, and nasal hemianopsia are very rare and indicate disease of the chiasma.

Bi-temporal hemianopsia, or loss of both temporal fields, is produced by disease of the middle of the chiasma destroying the crossed fibres (fig. 45, Z), and is found in acromegaly. In the *altitudinal* form the lesion is in either the upper or lower part of the chiasma, and the upper or lower parts of the field are affected. The *nasal* variety, from the position of the lesion (fig. 45, Y) producing it at the outer side of the chiasma, is probably never binocular, as it would be almost impossible to imagine two corresponding limited lesions occurring at the same time.

Homonymous hemianopsia may be either right or left, and also complete or partial. In the partial form, the defect of the field is generally equal and symmetrical in both eyes. The *symptoms* are sudden defect of vision, the patient usually complaining of difficulty in reading the whole of a line of print. The ophthalmoscope, as a rule, reveals nothing, and the acuity of distant vision may be perfect; on taking the field of vision, the exact loss of the field will be found out, but the abrupt line of demarcation between the blind and seeing part of the field rarely extends through the fixation point. This is due either to the fact that the yellow spot region receives fibres from both optic tracts, or to the difficulty experienced by the patient in maintaining accurate fixation. The hemianopsia is usually stationary; sometimes it may not be absolute, but only for colour (hemiachromatopsia).

Causation.—It may be due to hæmorrhage, cerebral tumour, or softening. The lesion producing the symptoms cannot be at the chiasma, but is either in the tract or its cerebral communications; it is generally very difficult to

localise. If in the *tract* it is usually complete, and the blindness is absolute. There may also be Wernicke's hemiopic pupillary reaction, in which light thrown on the blind half of the retina is not followed by contraction of the pupil, whereas light thrown on the unaffected half produces the ordinary contraction of the pupil.

The symptoms from lesions of the *primary optic ganglia* and *optic radiations* have not yet been sufficiently worked out to accurately determine a diagnosis.

If in the cortical portion of the *occipital* lobe, the hemianopsia may be complete or partial, and the blindness *relative*—that is, affecting only colour and form, the patient not having the sensation of darkness in blind portions of the field as in a lesion of the tract. As a rule, hemiplegia, aphasia, and paralysis of cerebral nerves are not present in cortical hemianopsia.

Certain symptoms have been found in connection with cortical hemianopsia, namely: *alexia* (word blindness), in which patients are able to see but not to understand written or printed characters; *dyslexia*, or inability to read more than a few words at a time without a feeling of disgust, though the print is not blurred nor the reading painful; loss of memory for the names of colours, and yet perfect facility for matching them.

Crossed amblyopia.—A few cases have been observed with lesion of the angular gyrus of one side, in which defective visual acuity on one side has been associated with concentric contraction of the fields of vision on the other side.

Coloured vision.—Patients occasionally complain of all objects appearing one definite colour, as red, green, blue, or white. The most common form is *erythropsia*, in which everything is seen of a red colour; it is most frequently met with after cataract extraction, and may last for a few hours or months; it does not affect the visual acuity. Treatment is of little avail, but the eyes

should be rested, and protected from bright lights by tinted glasses.

Scintillating scotoma[1] (teichopsia) is a condition occurring as a precursor of migraine, and generally found in intellectual persons. It is characterised by an appearance, starting from a small central dark spot, of angular spectral phenomena in the form of zigzag lines (fortifications), often coloured and scintillating. The field of vision is much contracted, and homonymous hemianopsia may be present. The attacks last about ten minutes, and are sometimes very frequent. The cause is probably central, due to vaso-motor changes in the vessels supplying the occipital lobe. The treatment is to improve the general health, and to remove all causes of overwork or fatigue. As a rule, the attacks indicate no serious trouble, unless associated with paresis or paralysis of limbs, or aphasia.

Congenital colour amblyopia (colour-blindness) is met with in males as frequently as four per cent., whereas in females it is only about two per cent. There is often a history of heredity, and deaf-mutes, Jews, and Quakers are especially liable to it. It is found, as a rule, in otherwise perfectly healthy eyes, and many people suffering from it reach adult life without finding it out. The causation and pathology of it are unknown, but probably there is a special centre in the cerebrum for colour perception. It is very rare for such patients to have no appreciation of colours (complete achromatopsia), the rule being that perception of one or two of the fundamental colours, red, green, or blue, is lost (partial achromatopsia).

There are two chief theories to explain the perception of colours. The first or physical theory, known as the Young-Helmholtz, attributes it to the existence of three

[1] Gowers, *Trans. Ophth. Soc.* xv. p. 1.

separate sets of fibres, red, green, and blue or violet, and patients would therefore be said to be red-blind, green-blind, or violet-blind. The second or physiological theory, propounded by Hering, divides the fundamental colour sensations into three pairs: white-black, red-green, and blue-yellow. For full description of these theories the reader must be referred to manuals on physiology and colour-blindness.[1] The most usual form is that of red or red-green blindness, in which the patient confuses certain shades of red and green. The methods of testing for colour-blindness are given on p. 36; and in the Appendix will be found a colour-vision plate with description. Treatment is of no avail.

[1] Foster, *Text-book of Physiology*, part iv. p. 1222. Abney, *Colour-vision*, 1895.

CHAPTER XV

DISEASES OF THE LENS

Anatomy.—The lens is a colourless transparent body, bi-convex in shape, with a refractive index of 11 dioptres, and more convex posteriorly than in front. It is avascular except in fœtal life, when it is nourished by the hyaloid artery, a branch of the central artery of the retina running in the hyaloid canal. After fœtal life, the nutrition of the lens is by imbibition of fluid from the ciliary processes. It is developed from epiblast, and is composed of long prismatic fibres, fitting by serrated edges into one another, and kept together by cement substance. These fibres are arranged in concentric lamellæ, like the layers of an onion, and the majority of them have a nucleus. Owing to the arrangement of the fibres there is a tendency for the lens to break into sectors, and these sectors may be seen at times with their divisions arranged anteriorly like an inverted Y, and posteriorly as the same letter in its normal or erect position. Lining the whole anterior surface of the lens is a layer of cubical epithelium, which does not extend normally to the posterior surface.

A homogeneous capsule encloses, and by its support aids the well-marked elasticity of the normal lens The encapsuled lens is retained in position by the *suspensory ligament,* consisting of fibres which pass from the elevations of the ciliary processes to the capsule, and are attached behind to the retina near the ora serrata;

this ligament does not in any way obstruct the filtration of the fluids. Around the border of the capsule is a small triangular space filled with fluid, called the canal of Petit. The space existing between the posterior surface of the iris and the suspensory ligament is known as the *circumlental space.*

The *fœtal lens* is smaller than that of the adult, and more globular in form. Up to the twenty-fifth year new lens fibres are laid down at the equator, and this leads to a continual increase in the transverse diameter. This increase is to a certain extent counteracted by a peculiar process of sclerosis, which affects the fibres of the lens from childhood to old age. In children and young adults [1] the lens fibres are of the same consistency throughout, and no nucleus is present. As age advances other changes take place; the texture becomes firmer, the colour yellowish, the refractive power and elasticity diminished, the size increased, and the more central portion becomes hard and sclerosed, forming the nucleus.

In elderly people, the lenses, in which these alterations appear, present to the naked eye a greyish appearance, which is apt to be mistaken for cataract, but examination by transmitted light at once dispels the error. The lens contains a great excess of globulin, and no albumen.

The function of the lens is to assist in collecting rays of light so as to focus them on the retina, and for this reason it is elastic and compressible when in its capsule.

Congenital abnormalities.—These include cataract, coloboma, lenticonus, and dislocation.

Congenital cataract and *dislocation* are described later on.

Coloboma lentis is a defect in the lens, in which a portion of the edge may be either straight, or more commonly notched. It is always situated below, never

[1] Priestley Smith, 'On the Growth of the Crystalline Lens,' *Trans. Ophth. Soc.* vol. iii. p 79.

extending as far as the centre or poles of the lens, and is usually associated with coloboma of other ocular structures.

Lenticonus is a very rare condition, in which the lens presents a conical projection at its anterior or posterior pole.

Cataract is the name applied to opacities situated in the lens and is more especially a disease of advanced life.

The *symptoms* are best seen in the *senile* form, and consist first of gradual diminution of the visual acuity, especially for near objects, as reading. If the lenticular changes are central, the patients see best in a dim light, which causes dilatation of the pupil; peripheral opacities may give rise to no diminution of acuteness of vision, so long as they do not reach the pupillary margin. Black or grey specks and lines are often seen by the patient and are due to shadows of the opacities thrown on the retina; they differ from vitreous opacities in being more fixed and in not appearing to float about independently of the ocular movements. Bright objects, as lamps, are seen as in a mist and surrounded by a yellowish halo. Monocular diplopia or polyopia, produced by the irregular refraction of the lens, may be complained of, and myopia may be developed in patients not previously short-sighted. As the cataract progresses the distant vision generally fails more quickly than the near, till both are reduced to vision of large objects, and sometimes to perception of light only. Unless the case be complicated by disease of other ocular structures, as the retina or optic nerve, there should, even in the densest cataract, be good perception and projection of light.

Signs.—Cataract is very rarely accompanied by inflammatory signs, and often the early stages cannot be diagnosed by the naked eye. When more mature the pupillary area looks grey or white, and this appearance may be mistaken for lymph, though in this latter case signs

of iritis are always present. When a cataract is suspected, the lens should be examined, first by focal illumination, when an opacity will appear as grey or dead white on a black ground, and then by direct ophthalmoscopic methods, which will cause the opacities to appear black on a red ground. As incipient cortical cataract may be easily overlooked, the pupil should be dilated by a mydriatic.

Cataracts are divided clinically according to their consistency into soft and hard. All cataracts in patients under thirty-five years of age are soft, and as a rule may be distinguished by having broad radiating striæ of a bluish-grey colour and metallic lustre, or an appearance like spermaceti. Above thirty-five years of age cataracts are hard, the striæ narrow, and the colour more or less yellow, and in some cases deeply coloured (black cataracts). When the cortex has lost all transparency, and no striæ or patches are present, the cataract is probably over-mature and liquid (Morgagnian).

Classification.—Cataracts are termed *primary* when independent of any other ocular affection, and *secondary* when consequent on some other ocular disease, as iritis, uveitis, glaucoma, &c., or when resulting from the remains of the capsule or lens substance after an operation for removal of the lens (best named *after-cataract*). Cataracts at first are incomplete or partial and may remain so or tend to become complete; the most satisfactory division is into Progressive and Stationary. *Progressive* cataracts are those in which the opacity tends, gradually or quickly, to spread, and as a rule ultimately to involve the whole lens; they may be subdivided into senile, traumatic and congenital. *Stationary* cataracts are so called when the opacity is permanently limited to one portion of the lens, and comprise lamellar, anterior polar and posterior polar.

Primary Cataracts

PROGRESSIVE CATARACTS.—The **senile** is the most common form, and is found as a rule in patients over fifty, though occasionally as young as thirty-five or forty. A class of cases, hardly deserving a separate description, is found in young adults, presenting the same symptoms as senile cataract, but the cataractous lenses are of course soft.

Senile cataracts may begin either in the cortex or in the nucleus of the lens, and occasionally at both places simultaneously. When beginning (*incipient stage*) in the cortex, they generally assume the form of streaks or radii (fig. 49), sometimes of triangular form, running towards the centre of the lens in the same manner as the spokes of a

A C B

FIG. 49.—CORTICAL CATARACT

A C B

FIG. 50.—NUCLEAR CATARACT

wheel converge towards its axle. These streaks appear white or grey (fig. 49, A) by oblique illumination, and black (fig. 49, B) when examined by the ophthalmoscope.

Instead of streaks the opacities may consist of numerous dots, and in cases showing signs of fœtal iritis there may be milk-white spots.

Occasionally flaws may be seen in the lens, as lines or round dots like small bubbles; these are generally the precursors of ordinary striæ. Cortical opacities may increase very slowly and remain almost stationary if there are very few; this is especially so in myopes, in which the cataract may never pass beyond the incipient stage.

When beginning in the nucleus the *incipient stage* is not at first well marked, the only sign being a deeply placed

greyish haze (fig. 50, A) in the centre of the lens, which is followed by an amber-coloured opacity. If examined by the direct ophthalmoscopic method the area of opacity is central (fig. 50, B), and prevents a clear view of the fundus being obtained through it, though the details may be well seen through the clear periphery of the lens.

The *maturing stage.* In a cortical cataract the striæ tend to run together and coalesce, and the nuclear layers generally become involved. In a nuclear cataract (fig. 50) the opacity increases gradually in size, and the cortex becomes involved. In all cases the last part of the lens to become cataractous is the extreme peripheral portion. During the *maturing stage* the lens tends to swell, and the anterior chamber thereby to become shallow.

The *mature stage* is reached when the whole lens becomes opaque, and by focal illumination there is no shadow thrown by the iris on the lens. The lens now shrinks a little, and the anterior chamber becomes normal again. In this stage nuclear cataracts are distinguished by their amber or yellowish colour, though occasionally they may be dark brown or black with metallic lustre, due to a colouring material like melanin or hæmatin (*black cataract*). Cortical cataracts are white or grey; if they form quickly in early adult life they are not so homogeneous-looking, and frequently have a peculiar sheen like mother of pearl or spermaceti.

Complete senile cataracts, after they have long existed, pass into the *over-mature stage*, when the cortex tends to become soft and liquid, and the sclerosed nucleus sinks to the bottom of the capsule in this milky fluid (*Morgagnian cataract*). Should the fluid become absorbed the anterior and posterior layers of the lens capsule come into contact (*membranous cataract*), and in this case the iris is tremulous.

Causation.—Senile cataract is essentially due to degeneration of the lens fibres, but the actual cause is un-

known. Subjects of this disease are generally grey-haired, wrinkled, and prematurely old. It is associated with arterial degeneration, gout, albuminuria and diabetes.

Pathology.—Several observers have found that the opacities are the result of rapid shrinking and hardening of the nucleus, accompanied by the presence of fluid between the cortical lens layers. This fluid causes a disintegration and opacity of the lens fibres, but the nucleus usually remains transparent.

Diagnosis.—There ought never to be any doubt after careful examination by the ophthalmoscope, except in cases where there is extensive disease of other ocular structures, such as the cornea and iris, or where the fundus cannot be illuminated, as in complete detachment of the retina.

The *prognosis* in a case of senile cataract is that it will in time become complete, but the length of time occupied in maturing is absolutely uncertain. It is the rule that nuclear cataracts mature more quickly than cortical. There are many cases, especially among myopes, in which a few cortical striæ appear, and remain for years without perceptibly increasing. In such cases a very guarded prognosis must be given, and often a patient is unnecessarily alarmed by being told that he is the subject of cataract; some such term as lenticular or cortical opacity would be sufficient explanation of his trouble. The loose employment of a popular term such as cataract has often a hopeless and unwarrantably depressing effect on the lay mind.

Treatment.—The only method of relieving a patient of cataract is removal of the lens by operation; no medicinal treatment, constitutional or local, possesses any curative power.

In the incipient and maturing stages, patients should be told to rest the eyes as much as possible, and to avoid sitting before a hot fire, as people exposed to extreme

heat, such as stokers, are liable to cataract. In patients suffering from diabetes, albuminuria, &c., careful dieting and treatment ought to be carried out, as the maturing of a cataract is hastened by failure of general health. When myopia supervenes, suitable glasses should be prescribed. In nuclear cataract the sight may be improved by dilating the pupil by means of weak atropine drops ($\frac{1}{2}$ grain to the oz.), which enables the patient to see through the periphery of the lens. It is important that a patient suffering from cataract should be seen from time to time, as occasionally whilst he is waiting for it to become mature, some other ocular disease, as glaucoma, may independently develop.

The operative treatment is by extraction of the lens, with or without iridectomy, as described on page 226.

Traumatic cataract follows as a rule perforating wounds of the lens capsule, but a form (*concussion cataract*) results from non-perforating blows on the eye, probably in consequence of rupture of the capsule.

Course.—Within a few hours after a perforating wound, the lens, by imbibition of the aqueous, becomes opaque at the seat of injury, and tends to swell. Soft whitish flakes of lens substance protrude through the rent in the capsule and fall into the anterior chamber. The tendency is for the softened lens substance to become absorbed, and in young patients spontaneous cure of the cataract may thus result. As a rule, however, part of the lens remains permanently opaque inside the capsule. In patients over forty the course is not so rapid, and, owing to the hardness of the lens, spontaneous cure never results.

In a *concussion cataract* the lens generally remains permanently opaque, and if left long enough may undergo some of the secondary changes described under the senile variety.

Complications.—Either from the introduction of germs at the time of the injury, or from swelling of the

lens afterwards, iritis, iridocyclitis, panophthalmitis, or secondary glaucoma may arise.

Treatment.—When following a perforating wound the pupil must be dilated by atropine to prevent posterior synechiæ and iritis.

If the intra-ocular tension is much increased the lens substance should be evacuated by a corneal incision without or with iridectomy.

Congenital cataract is rarely met with, if we exclude the lamellar variety. It is a bilateral form, and resembles senile cataract in appearance, being either yellowish or whitish-grey, and is generally associated with defects of the retina or choroid. If untreated, nystagmus often develops. It is difficult to say whether infants with congenital cataract have the power of vision, but if perception of light exists an infant will follow with his eyes a candle moved in front of his face. The treatment is to break up the lens by discission, but occasionally the capsule is too hard, and then the lens must be extracted, an operation frequently attended with bad results.

STATIONARY CATARACTS. — **Lamellar** (*zonular*) **cataract** (fig. 51), affecting as a rule both eyes, is either congenital or forms in early life, and is the most common variety of cataract found in children. It consists of a disc-like opacity with clear lens substance on its inner and outer surface.

FIG. 51.—LAMELLAR CATARACT

The *symptoms* are only those of defective vision, and vary greatly in amount according to the size and position of the opacity. The first *signs* observed are dulness and alteration of the normal black appearance of the pupil. With a dilated pupil a hazy disc or shell is seen in the lens surrounded by a clear peripheral zone. This disc (fig. 51, A) may be seen to lie between the central portion and the

cortical layers of the lens, and consists of greyish dots and striæ; some of these lines project into the clear zone like the spokes of a wheel, and sometimes take the shape of the sectors of the lens. By direct ophthalmoscopic examination (fig. 51, B) the cataract appears as a dark grey disc, thinner generally in the middle, and surrounded by a ring of clear red reflex; the details of the fundus, though indistinct, can be seen through the opacity, thus distinguishing it from a nuclear cataract.

Causation.—It is frequently hereditary, and as a rule associated with a deficiency of the enamel producing a striated and roughened appearance of the teeth; there is generally a history of convulsions during infancy and signs of rickets, especially cranio-tabes.

Pathologically,[1] no changes of importance are found in the cortical layers, but the line of demarcation between the cortical and central portions is abrupt, and formed by granular degeneration of the fibres.

The disease is as a rule stationary, but may occasionally progress.

Treatment.—Sometimes sight is very little affected, and an operation will not improve it. In all cases the vision for distant objects should be taken with and without a mydriatic, as atropine, and if the distant vision improves greatly under atropine an iridectomy should be performed downwards and inwards. If the vision is very defective and cannot be improved, the lens should be broken up or extracted. The advantage of iridectomy over removal of the lens is that the patient does not require high convex lenses and often retains his power of binocular vision.

Anterior polar (pyramidal) **cataract** (fig. 52), generally chalk-white in colour, of small size and with sharply defined edges, is situated at the anterior pole of the lens beneath the capsule. It is frequently accompanied

[1] Lawford, *Trans. Ophth. Society,* vol. xii. p. 184.

by a central corneal nebula, and then results from a perforating ulcer of the cornea. In other cases, it is probably produced by inflammatory changes during fœtal life, as owing to the absence of the anterior chamber, the globular lens is in contact with the posterior surface of the cornea, and any swelling of the cornea or lens would tend to interfere with the nutrition of the anterior pole.

FIG. 52.—ANTERIOR POLAR CATARACT

This condition does not call for treatment.

SECONDARY CATARACTS.—**The progressive form** is a sequela of some inflammation or degenerative process of the eye. It is found especially in cases of atrophy and degeneration of the ciliary region, as in cyclitis, uveitis, glaucoma, and detachment of the retina. These cataracts tend soon to degenerate, and may become calcareous.

The *treatment* in such cases is by extraction or discission, unless the condition of the eye renders it impracticable. Owing to their origin such cases are very unsatisfactory to treat.

The term *secondary cataract* is sometimes applied to the capsule, lymph, and soft lens matter left in the pupillary area after an operation for removal of cataract, but such cases are best designated *after-cataracts*.

FIG. 53.—POSTERIOR POLAR CATARACT

Posterior polar cataract (fig. 53) is the stationary form of secondary cataract. It is greyish in colour (fig. 53, A) and situated in the layers of the lens, near the posterior pole, from which it radiates like the spokes of a wheel. It is not so localised nor so sharply

defined as the anterior polar, and is associated either with disease of the vitreous, choroiditis, or retinitis pigmentosa. Vision is as a rule impaired, but more by the complications than by the opacity.

This form does not admit of treatment.

THE OPERATIVE TREATMENT OF CATARACT.

Artificial pupil. — In lamellar, and occasionally nuclear cataract, when the opacity is about the same size as the normal pupil, and is *stationary*, the vision is often much improved when the pupil is dilated, as in a dim light or under a mydriatic. In such cases a small iridectomy (p. 117) downwards and inwards corresponding to the line of vision is to be preferred to extraction of the cataract.

This procedure possesses this great advantage to the patient that glasses need not be worn, unless a previous error of refraction or accommodation be present, and also the operation assists a subsequent extraction if such should be required.

Cataracts, which are necessarily soft when occurring in patients under twenty-five years of age, may be removed by discission, linear extraction, or by a combination of both methods.

Discission is the laceration of the anterior capsule of the lens with a needle, in order that the aqueous fluid may gain access to the lens substance, and so procure its absorption. As a rule the operation has to be repeated several times before the lens substance is completely removed, and this necessarily occupies a considerable period of time, varying from two to six months.

It is indicated in cases of lamellar, congenital, and some forms of traumatic cataract, and lately it has been employed for the removal of the lens in cases of high myopia. Atropine should be dropped into the eye the night before and the morning of the operation, so that the pupil should be well dilated.

Anæsthetics.—In very young children it may be necessary to use chloroform, but cocaine is almost always employed.

The *instruments* required are speculum (fig. 23), fixation forceps (fig. 19), cataract needle (fig. 54) (this last should be very sharp, slightly tapering towards the end, and rounded in section, so as to prevent escape of aqueous). The operation may often be performed with a needle only;

FIG. 54.—CATARACT NEEDLE

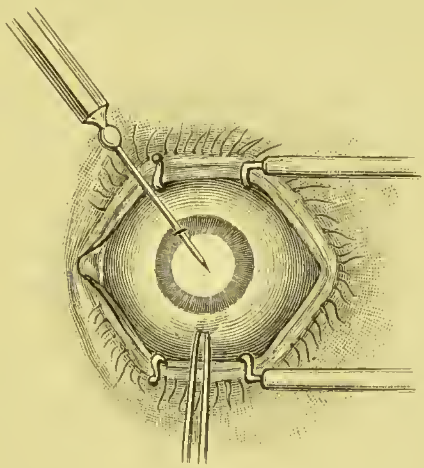


FIG. 55.—DISCISSION OPERATION

in such cases the lids are held open, and the eyeball fixed by the fingers of the operator's left hand.

Operation (fig. 55).—The eye having been well washed with an antiseptic solution, and the speculum introduced, the operator stands behind the head of the patient, and fixes the conjunctiva below the corneal margin with the fixation forceps. Holding the needle in his right hand he passes the point of it firmly, gently, and slowly through the cornea about 1 mm. anterior to its periphery and preferably above and to the outer side. The needle is

now directed downwards and inwards into the anterior chamber until its point is seen opposite the middle of the pupil. Then, using the handle as a lever, the operator depresses the point and tears the anterior capsule near the centre.

Care must be taken, if it is the first operation, that a very small opening is made in the capsule, but if it is the second or third operation, the needle may be used much more freely and the lens substance stirred up and torn.

The needle is now slowly withdrawn, and this is followed by a spurt of the aqueous through the wound.

The conjunctival sac is washed out, atropine instilled, and the eye bandaged up.

It is occasionally necessary, owing to the thickness of the capsule, to use two needles, introduced at opposite sides of the cornea, so that the capsule may be torn apart by their points.

Course.—At first no effect may be seen, but in a few hours the capsule and anterior lens substance become grey and white at the point of incision. In a free discission flakes of lens substance pass into the anterior chamber and mostly occupy its lower part; the aqueous fluid becomes turbid and there is slight ciliary congestion, and lachrymation. The whole lens gradually swells up from imbibition of fluid and becomes softened.

Sometimes in young children one discission suffices, but as a rule two or three operations are necessary.

The importance of making the first operation a very slight one is that the reaction cannot be gauged beforehand, and varies with the individual. Sometimes the slightest incision of the capsule is followed by the whole lens coming forward into the anterior chamber, while at other times little or no result is obtained. As the object of the operation is to gradually soften and remove the lens substance by absorption, anything approaching heroic needling is to be condemned.

Discission is always followed by slight ciliary congestion and a tendency to increased tension; this latter symptom must be very carefully watched for. After the lens substance has been absorbed, the pupil is generally more or less blocked by opaque capsule, which must be needled or divided by a Graefe's knife.

Accidents and complications.—The most likely accident to occur during the operation is that the needle may puncture or tear the iris; this, except for slight hæmorrhage at the time, is not serious. Occasionally the posterior capsule may be lacerated by the needle being passed in too far, and to avoid this risk, stop needles provided with a shoulder may be used.

The complications are chiefly due to the irritation of the swollen lens substance, which may give rise to iritis, cyclitis, or glaucoma, and septic infection may be set up if the needle is not absolutely clean.

The patient should remain in bed with the eye bandaged for at least twenty-four hours after the operation, and the pupil must be kept well dilated by atropine. It is a good plan to apply cold compresses to the eye for forty-eight hours after the operation, so as to keep down any inflammatory reaction. When the bandages are left off the eye should be protected by a shade or by a pair of tinted glasses. Pain may be relieved by leeches, and any glaucomatous symptoms should be treated by paracentesis of the anterior chamber, or by linear extraction.

Linear extraction is the removal of a soft lens through a small incision in the cornea. It is more frequently employed after discission operations than for the removal of a cataract at one sitting. The *instruments* required are speculum (fig. 23), fixation forceps (fig. 19), keratome (fig. 33), curette (fig. 25), and tortoise-shell spoon (fig. 61). The operation is generally performed under cocaine.

Operation.—The speculum being introduced and the conjunctival sac washed out, the operator fixes the eye at the outer side with the forceps, and passes the keratome through the cornea, about 1 mm. from the periphery, into the anterior chamber. The corneal incision, as the name (*linear*) of the operation implies, is a straight one, 4 to 5 mm. long, and is generally situated below and to the inner side. In cases where discission has not previously been performed, the anterior capsule is now divided by a cystotome (fig. 58). The operator then passes the curette through the wound and allows the soft matter to escape along its groove. By careful manipulation of the curette, and counter pressure at the periphery of the cornea by the spoon, nearly all the soft matter may be evacuated. When no more soft matter can be extracted the operator clears any débris away from the edges of the wound with the curette, and after making sure that the iris is free, bandages up the eye.

Prolapse of the iris through the wound may occur, and should be carefully replaced by the curette. If after the operation is concluded there is any doubt as to the iris being caught in the wound, an iridectomy should be performed.

Unless carefully manipulated, the curette may perforate the posterior capsule, and allow the vitreous to escape, or it may bruise the iris, setting up iritis.

The after treatment is the same as for discission, but the patient is generally kept in bed and the eye bandaged for a longer time. Care must be taken not to use atropine too freely at first, as there is always a tendency to prolapse of iris.

Suction operation.—Some operators use a syringe to remove the soft matter after discission, instead of a curette, but this method is seldom employed now.

The steps of operation are the same as those of linear

extraction, but the incision through the cornea should be situated about 3 mm. away from the periphery, and should be only large enough to admit the nozzle of the syringe.

The syringe (fig. 56) being introduced through the corneal wound, and its end kept carefully in the anterior chamber, gentle suction is employed, and the soft lens matter passes into the syringe. Great care must be taken not to employ undue force, or the posterior capsule may be ruptured. The advantage of this method is simply in saving time, and it must be remembered that it is more difficult to perform, and hence less safe, than an ordinary linear extraction. The syringes usually employed are known as Bowman's and Teale's, and must be very carefully rendered aseptic before the operation.

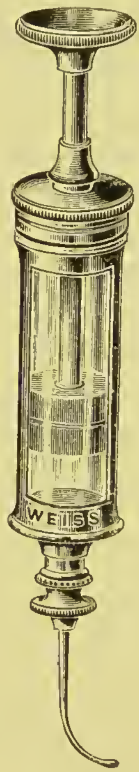


Fig. 56.—Cataract Syringe

The only objection to the discission operation for soft cataracts is the length of time the lens takes to absorb, and undoubtedly the best treatment in most cases is by the combination of discission and linear extraction. My own practice is to make a first slight central needling, and if little reaction takes place to make a free needling two days afterwards. This is often followed by a third needling in about a fortnight, and if necessary about two months after the first needling most of the lens matter is let out by a linear extraction.

It is best now to wait for a month or six weeks before again operating, either by linear extraction, if much soft matter is left, or generally by a needling operation for opaque capsule.

If both lenses are cataractous, the other lens may be operated on (unless the reaction in the first eye be very severe), during the course of treatment of the first eye, preferably after the second needling.

Senile cataracts, or even in some cases soft cataracts, may be removed in their entirety at one sitting. The usual term for such an operation is 'extraction,' but it must be remembered that this word is applicable to any operation in which lens substance is removed from the eye, as by linear extraction, &c.

As extraction of a senile cataract is the most important operation in ophthalmic surgery, the precautions and rules to be observed before, during, and after operating are fully described here. Many of these apply equally to the other cataract operations.

Rules for operating.—A cataract should, if possible, never be extracted until it is mature. This condition is attained when the lens is uniformly opaque, and the shadow thrown by the edge of the iris on the lens is absent. (This examination should always be made with a dilated pupil.) If immature, a cataract does not shell cleanly out of the capsule, and the cortex, being tenacious and viscid, is with difficulty removed; also the presence of much soft matter in the eye after extraction gives rise to severe inflammation.

In ordinary cases, it is the custom to operate when the cataract in one eye is complete, and the other advanced so far as to render vision very imperfect. To this rule there are many exceptions, and each case must be decided on its own merits.

Surgeons should be very careful, when giving the usual advice that patients must wait till the sight of one eye is nearly gone and that of the other much impaired, to insist on the necessity of examination of the eye from time to time. In some cases chronic glaucoma or other ocular disease supervenes, and the patient may become

quite blind and beyond treatment whilst waiting for the cataract to ripen.

The lens may be extracted in a case of mature cataract, although the vision of the other eye is only slightly affected, or is even normal, under the following circumstances :—(1) When the patient follows an occupation, as bricklaying, which needs good perception of objects on both sides. (2) If the impairment of vision of both eyes for some time would cause him to lose his situation, the operation would ensure him an eye ready for work, with suitable glasses, when the vision of the other eye becomes insufficient. (3) If the patient is going to a foreign country for some time, where he could not obtain good advice or treatment. (4) If the cataract has existed for some years, and is likely to become over-mature, and therefore more dangerous to extract. (5) If the presence of cataract occasions great anxiety to the patient, and consequent loss of sleep and general constitutional disturbance. In the young especially, a cataractous lens may be extracted for cosmetic reasons, as the grey or white appearance of the lens is very disfiguring, and may prove a detriment in finding employment.

Unless under exceptional circumstances a double extraction (removal of both lenses) should never be performed at one sitting.

When both lenses are cataractous, and tend to mature nearly at the same time, an operation for maturation of one cataract may be performed.

Occasionally there is a small nuclear cataract in both eyes, and double iridectomy downwards and inwards may greatly improve the vision for a time.

Precautions to be observed before operating.—A careful and methodical examination of all parts of the eye, including its appendages, should be carried out. Any inflammation of the lachrymal sac, lids, or conjunctiva must be treated, and, if possible, cured, before any

operation is undertaken, owing to the danger in such case of introducing germs into the eye at the time of operation. Corneal opacities do not, as a rule, contra-indicate operative measures. In all cases of incipient cataract the fundus is to be carefully examined for future reference.

When the cataract is complete, there still remain sources from which the state of the deeper parts of the eye—namely, the vitreous, retina, and choroid—can to a certain extent be determined. Thus it must not be forgotten that the condition of the corresponding part in the opposite eye may afford some indication, as vitreous opacities, choroidal and retinal changes are not infrequently symmetrical. The tension of the eye must always be estimated. The condition of the retina in a complete cataractous eye should be examined by the '*projection*' method. This consists in throwing the light reflected from an ophthalmoscopic mirror through the opaque lens and coat of the eyeball upon the inner, upper, outer, and lower portions of the retina If the light so thrown can be seen well and equally distinct all over the retina, and the patient states accurately the direction whence the light comes, it may be presumed that the fundus is healthy. In uncomplicated cataract, even when quite opaque, there should be good perception and projection of light even at a distance, and frequently in mature cataract fingers can be counted.

A complete cataract in a patient under forty years of age is to be looked upon with suspicion.

Notwithstanding all these precautions, there are cases of central choroidal changes which cannot be diagnosed by projection, and which prevent a good result, as far as vision is concerned, after operation. It is these cases especially that must make the surgeon guarded in the prognosis as to vision, unless the fundus can be examined thoroughly.

The general health should be investigated, and any

cause likely to produce straining, such as cough or constipation, carefully attended to. The presence of diabetes and albuminuria are unfavourable to operation, though many patients suffering from these diseases do well.

As the operation of extraction is not one of urgency, the following immediate precautions should be observed :—The bowels should be attended to the night before the operation; the patient should be used to his surroundings, especially his bed, for at least twenty-four hours previously; no great exertion, such as a long railway journey, should be taken the day before ; the coldest and hottest times of the year should be avoided; the hygienic conditions, especially the drainage of the house, ought to be perfect; the operation should, if possible, be done early in the morning, so that the patient may have time to recover from the effects before his usual hour for sleep.

The pupil should not be widely dilated with atropine, especially if cocaine is to be used, as the large size of the pupil makes it difficult to do a small iridectomy, and also, if no iridectomy is done, the danger of prolapse is greater with a large pupil.

Prognosis.—If the cataract be mature, the other ocular structures normal, and the patient's general health good, a favourable result is to be anticipated. The history of previous ocular disease, as glaucoma, iritis, or the presence of diminished tension, demands a very guarded prognosis, which must also be given in cases of diabetes, albuminuria, and a complete cataract in a patient under forty years of age. Corneal trouble, unless complicated with disease of deeper structures, only affects the prognosis as to the amount of vision afterwards.

Operations.—Since the introduction by Daviel (in 1750) of extraction by a flap occupying the lower two-thirds of the cornea, numerous modifications and improvements in the operation have been adopted by ophthalmic surgeons. These have been chiefly in the position of the

incision and the employment or non-employment of iridectomy. Gibson in 1811 introduced the linear incision instead of the flap for soft cataract, and Von Graefe in 1865 originated the modified linear operation combined with an iridectomy.

The **modified linear operation** was practised almost exclusively for some years. The incision was made by a Graefe's knife (fig. 57), the puncture and counter-puncture lying beyond the sclero-corneal junction, and the knife made to cut its way out in the sclera. The section was, therefore, scleral rather than corneal. A large iridectomy was then performed and the lens extracted. The objections to this method are that the conjunctival section often gives rise to considerable hæmorrhage; the edges of the iris are liable to be caught in the wound; from the scleral position of the section vitreous is frequently lost; the lens does not present itself readily, and there is a slight risk of sympathetic inflammation.

Of late years most operators have reverted to the corneal flap, which, however, is of much smaller size than it was originally, and is generally known as the three-millimetre corneal flap operation, and may be performed with or without iridectomy.

The question of iridectomy or non-iridectomy in cataract extraction has been more discussed than any other point in the operation. There is no doubt that a successful extraction without an iridectomy is by far the more desirable operation. The coloboma of an iridectomy disfigures the appearance of the eye, proclaims the existence of disease to the outside world, and, as a rule, reduces the acuity of vision, owing to the increased size of the pupil and the dazzling effect this produces; whereas, the central non-mutilated pupil does not affect the personal appearance and acts as a perfect diaphragm. The points generally advanced in favour of iridectomy are that the lens can be more easily delivered, especially if there be much soft

matter, and that there is little danger of prolapse of iris. This prolapse of iris is the great objection to the extraction without iridectomy, but the situation of the section in the corneal tissue, and the replacement of general anæsthetics by cocaine, have rendered the accident much less frequent. In all cases of complete cataract, where the patient is not suffering from cough, or any disease which necessitates straining, I operate without an iridectomy, but in cases of incomplete or over-mature cataract, I prefer an iridectomy, owing to the difficulty of removing the soft lens substance without bruising the iris. One great point in favour of operating without iridectomy is that it may be performed without any hæmorrhage; an iridectomy must always be done if there are numerous posterior synechiæ or if the tension is raised.

Many operators prefer a preliminary iridectomy some months before the lens is extracted, and hence make two separate and distinct operations, the *first* being the performance of a small iridectomy (p. 117), and the *second* the extraction operation, being practically the same as the operation without iridectomy (p. 230). There is little doubt that this plan is the safest, but it takes longer, and involves extra worry and trouble to the patient. It should always be employed if the patient has only one eye, or if the cataract is not fully matured.

Maturation of cataract.—In certain cases where it is necessary to hasten the course of a cataract an operation may be performed for this purpose. This is done by tapping the anterior chamber with a small keratome, and when it is empty rubbing the surface of the cornea firmly with a tortoiseshell spoon (fig. 61), and in this way producing pressure on the lens.

Some operators bruise the anterior capsule of the lens directly by introducing a spatula through the corneal section; others perform an iridectomy at the same time.

The 3-Millimetre Corneal Flap Operation

Anæsthetics.—The operation is performed as a rule under cocaine, and for this purpose one or two drops of a 4 per cent. solution of cocaine should be placed in the eye three times, at intervals of five minutes, starting ten minutes before the operation. When an iridectomy is to be done, another application should be made after the corneal section. The disadvantages of cocaine are slight, being chiefly due to flaccidity of the cornea, which renders the corneal section and extraction of the lens more difficult; cocaine solutions keep badly, and unless they be freshly made, septic inflammation may be set up. If from nervousness of the patient a general anæsthetic must be used, chloroform is to be preferred to ether, as the latter tends to produce congestion of the eye. The grave objection to general anæsthetics is their tendency to induce vomiting, which may occasion subretinal hæmorrhage or prolapse of the iris or vitreous.

Position of the patient.—He should be lying on his back on a table, with his head supported on a pillow. The light should be good and should proceed from the same side as the eye to be operated on.

Preparation of instruments.—All instruments except knives are to be boiled in distilled water immediately before the operation, and then placed in boracic acid solution or distilled water; the knives should be dipped in boiling water first, then in absolute alcohol, and placed in distilled water till used.

Position of the operator.—If operating on the right eye, he should stand behind the head of the patient, holding the knife in his right hand, and if he is ambidextrous he takes the same position, using his left hand for the knife when operating on the left eye. If the operator cannot so use his left hand, he must come round

in front and to the left of the patient, and hold his knife in the right hand.

Assistants.—The operator should have at least one assistant to hand him the instruments, and, if necessary, to steady the eye by means of the fixation forceps. Both operator and assistants should scrub their hands and nails with soap.

The 3-millimetre flap operation with iridectomy. (*Right eye.*)—The instruments required are speculum (fig. 23), fixation forceps (fig. 19), knife (Graefe's) (fig. 57), iris forceps (fig. 34), iridectomy scissors (fig. 35), cystotome (fig. 58), curette (fig. 25), and spatula.

Fig. 57.—Graefe's Knife.

Fig. 58.—Cystotome.

Corneal section.—The operator, having introduced the wire speculum, fixes the conjunctiva about 2 mm. below the cornea with the fixation forceps held in the left hand as shown in fig. 59, and by this means keeps the eye steady. Taking the knife lightly between the thumb and first two fingers of the right hand, he passes it through the outer part of the cornea at a point situated just within its margin and at a distance of 3 millimetres from the highest point of the cornea. He then directs the knife across the anterior chamber in front of the iris to a point within the periphery of the cornea, on the nasal side, exactly

corresponding to the original puncture. By this means the knife, on making the counter-puncture, should lie in a horizontal line with its cutting edge upwards. By a slow to and fro movement the knife is now made to cut its way out in an upward direction through the periphery of the cornea. Care must be taken that the section is throughout in the cornea and that the knife is always kept parallel to and in front of the iris. The corneal section, as shown by the dotted lines in fig. 59, is in the shape of a flap with its convexity upwards.

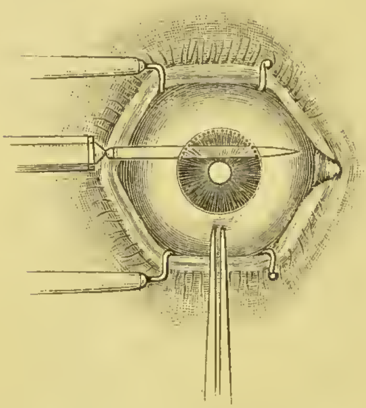


Fig. 59.—Corneal Section

Iridectomy stage.—The patient, if under cocaine, is now instructed to direct his gaze at his own hand, held slightly raised; if he cannot be relied upon to keep still, the eye is steadied by fixation forceps entrusted to an assistant to hold, as is always done in patients under a general anæsthetic.

The operator now introduces the iridectomy forceps, held in his left hand (see fig. 37), with their points closed, through the middle of the wound, and passes them into the anterior chamber until the points reach the upper pupillary border of the iris. He then gently relaxes his pressure on the handles of the forceps, and seizing firmly the pupillary border of the iris, he slowly draws the portion of iris held by the teeth of the forceps through the middle of the wound. With the iridectomy scissors held in the right hand, he now proceeds to cut off the withdrawn portion of the iris lying between the forceps and the corneal wound. This may be done by cutting, as in

fig. 37, parallel to the wound, or across the cornea from below upwards at right angles to the wound.

Capsulotomy.—A cystotome, held in either hand, is introduced through the wound with its blunt edge downwards, and is then rotated till its point is on the capsule, which by gentle lateral movements is incised. Some operators prefer to incise the anterior capsule freely, and over its whole surface, while others aim at incising only the upper portion. Great care must be taken not to press backwards with the cystotome, or the lens may be dislocated.

Delivery of the lens (fig. 60).—If under cocaine, the patient is now told to direct his gaze downwards, and

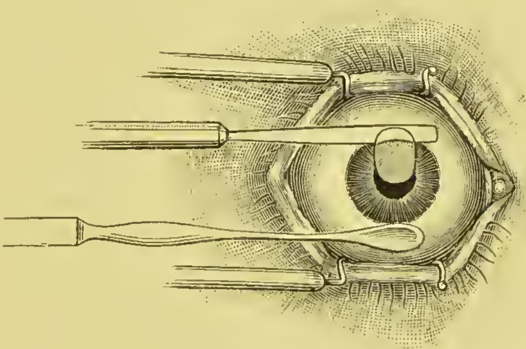


Fig. 60.—Delivery of Lens

moderate pressure by the curette or tortoiseshell spoon (fig. 61), held in the right hand, is applied over the sclerotic below the cornea till the upper edge of the lens presents itself in the wound. This pressure is continued firmly, but gently, till the whole lens is gradually delivered. As in fig. 60, a good plan is to apply a spatula, held in the left hand, over the upper edge of the wound, as by this means the lens is kept forwards, and delivered over the spatula. If the lens sticks it may be brought out by the cystotome.

After the lens is delivered the speculum may be taken

out and the eyelid closed for a few seconds. In most cases some soft lens matter will have been left behind, and this must now be evacuated through the wound, by pressing below the cornea with the curette until the pupil appears quite black. A very good way is to apply the pressure by rubbing the lower lid over the lower part of the cornea, and sponging away the soft lens material as it is presented at the wound.

Fig. 61.—Tortoise-shell Spoon

Replacement of iris.—After the pupillary area has assumed a black appearance, the operator should introduce a curette or spatula at one side of the wound, and push the iris edge towards the centre of the cornea till he can see that the angle, formed by the cut edge of the iris and the pupillary margin, is in its proper position. After repeating this procedure at the other side of the wound, the operation is completed. The pupil should now present an appearance as in fig. 38, A.

The 3-millimetre flap operation without iridectomy.—Most of the details of this operation are similar to the last, and therefore only the points of difference are described below.

The *instruments* required are speculum, fixation forceps, a knife (Graefe's), cystotome, curette, spatula, and tortoiseshell spoon

The *corneal section* is the same as in the preceding operation (p. 227).

The *capsulotomy* is similar, but great care must be taken not to injure the iris by the cutting edge of the instrument, and the capsule must be divided in its central portion, owing to the pupil being intact.

Delivery of lens.—On pressure with the curette or spoon below the cornea, the iris must be encouraged to prolapse, as the lens has to pass through the pupillary area as well as through the corneal wound.

Replacement of iris.—The prolapsed iris, after delivery of the lens, is pushed gently back through the wound into the anterior chamber by means of a spatula, and the speculum being taken out, the lids are closed for about half a minute, and the soft lens matter removed as above. On now opening carefully the lids the pupil should be central, moderately small, and round. If it is not so, the cornea should be rubbed by the spatula near its centre, and if this does not succeed, the spatula should be again introduced through the wound, and the iris pushed gently inwards. If, however, the pupil remains large and irregular in shape, an iridectomy should be performed, as there would be great danger of prolapse of the iris. Eserine is, as a rule, dropped in the eye to contract the pupil. After the iris has been replaced, the eye should be washed out with distilled water or boracic acid solution, and the lids carefully closed.

The *dressings* necessary are two circular pieces of soft linen, cut large enough to cover the eyelids, and smeared with a simple ointment, as boracic acid, pads of absorbent cotton wool, and a bandage. One of the round pieces of linen should be placed over each eye, and covered with small smooth pieces of absorbent cotton wool of about the same size. The amount of wool to be used depends upon the prominence of the eye or depth of the orbital hollow; actual pressure is not requisite unless vitreous has been lost. Both eyes are lightly but securely bandaged up, in order to keep the dressings in place. The patient is now lifted into bed, and told to lie on his back with the head resting on a low pillow. If possible, it is a good plan, especially if an iridectomy has not been done, to leave him on the operating table for half an hour

or so, to afford the eye complete rest, and to allow the patient to recover somewhat from the shock of the operation.

Complications and accidents during the operation. *Corneal section.*—If the incision is found to be too small, the wound may be enlarged at either or both ends by a pair of iridectomy scissors. If the puncture or counter-puncture be too peripheral, a conjunctival flap is formed and may give rise to hæmorrhage. Great care must be taken to see that the knife is not introduced with its cutting edge below instead of above. If this accident happens, the knife may be drawn out and the operation deferred till another day; or, if the aqueous has not escaped, the knife may be rotated and the section made as usual. In this latter case there is great danger of the iris falling over the knife.

If the iris falls over the knife during the section, the operation may still be completed as usual, but the iridectomy thus effected is generally irregular and misshapen. It is better to try to release the iris from the knife by applying pressure on the cornea by the finger, and then completing the section by moving the knife forwards.

Occasionally, on the first puncture of the cornea by the knife, the aqueous escapes and it is impossible with safety to make the counter-puncture. In such cases the knife should be withdrawn and the operation postponed.

In passing the knife across the anterior chamber to make the counter-puncture, the point may touch or wound the iris; the knife should be slightly drawn back and disengaged from the iris, and the counter-puncture then made.

If the counter-puncture be not in the proper position, the knife should be withdrawn a little, and the counter-puncture made again in the proper place.

During the iridectomy stage, there may be considerable

hæmorrhage into the anterior chamber, and this may be let out by introducing a curette through the wound, or by pressing with it on the cornea from below upwards. The presence of the hæmorrhage should not interfere with the incision of the capsule, which may be proceeded with as usual.

If the sphincter portion of the iris escapes division during the iridectomy, it should be divided by a pair of sc ssors; otherwise it may hinder the escape of the lens.

Capsulotomy.—If the capsule is too hard to perforate with a cystotome, it may be incised by a Graefe's knife, or the lens extracted in its capsule by a spoon (fig. 62) or vectis (fig. 63). When doing capsulotomy, the lens may be seen to shift its position owing to weakness of the suspensory ligament, and in these cases, if it does not tend to come easily forwards by pressure, it should be extracted by a spoon.

Fig. 62.
Cataract Spoon

Fig. 63.
Vectis

Delivery of lens.—If the lens does not present itself, this may be due to the corneal incision being too small, to the capsule of the lens not being sufficiently lacerated, or to a tendency to backward dislocation of the lens. In such cases, the corneal wound should first be cleared by passing the curette along it, and the cystotome may again be used; failing these means, the corneal wound should be enlarged by scissors, and as a last resource the lens must be delivered by a spoon. If whilst applying pres-

sure, the vitreous be seen as a black object through the wound, great care must be taken not to apply too much pressure, or the hyaloid membrane will rupture with subsequent loss of vitreous. In such cases the delivery should be made at once with a spoon, as the lens may dislocate backwards. If the lens dislocates backwards, it must be searched for with a spoon in the vitreous chamber, and removed at all costs, as if left it would set up inflammation of the uveal tract.

Loss of vitreous may occur before or after delivery of the lens. It is caused by too much pressure on the eye, and is generally associated with a weak suspensory ligament. If the vitreous is lost before the lens is delivered, all pressure should be taken off the eye and the lens removed by a spoon or vectis, as otherwise pressure would only tend to dislocate it backwards. If it happen after delivery of the lens owing to the pressure of the speculum or introduction of instruments, the vitreous protruding through the corneal wound should be cut off with a pair of scissors, and the eye firmly bandaged. The wound in such cases always takes longer to heal, and forms a larger and denser cicatrix.

Sometimes the cornea, after the lens is removed, may fall inwards and present a cupped appearance. This is generally seen when cocaine has been used, and need not cause anxiety, as the cases do well if a firm bandage be applied after completion of the operation.

The most fatal accident of all is deep intra-ocular hæmorrhage, in which case the eye is always lost for vision; the vessels are generally diseased, and the hæmorrhage is between the choroid and sclerotic.

Course.—The normal course after extraction is for the edges of the corneal wound to become applied to one another, and in twenty-four hours the anterior chamber should be reformed. The union of the corneal incision is accompanied by slight vascular congestion and generally

a little lachrymation, but there should be no marked swelling of the lids or coloured discharge from the eye. If the case is not taking a normal course, the eyelids become red and swollen, especially towards the nasal side, and there is usually discharge on the dressings and along the lashes. On depressing the lower lid the conjunctiva is congested and often chemosed. Unless these symptoms be present, the surgeon should refrain from inspecting the eye itself till the wound has healed: curiosity cannot be too strongly deprecated. The wound should be firmly healed by the end of the seventh day.

Owing to the return of sensibility following the anæsthesia of the cornea the patient generally complains the first night of a little pain and lachrymation, and often for a few days the eye has a gritty and itching sensation.

After treatment: *Local.*—If the eye has been operated on in the morning the bandages may usually be removed the same evening if the patient has any discomfort. This must be done very carefully, and it is advisable to remove first the dressings from the sound eye, which should always be treated as if it were the operated-on eye, in order to accustom the patient to the necessary manipulations. The best way to dress the eye is to soak a pledget of absorbent cotton wool in boracic acid solution, and to bathe the side of the nose, so as to avoid the shock and consequent movement of the patient if the eyelids are first bathed. The palpebral portion of the lid and the eyelashes are then gently washed backwards and forwards with another pledget. The lower lid is carefully pulled down by the finger of the surgeon, so as to allow any pent-up tears to escape; during all these proceedings the patient is instructed to keep his eye closed. Exactly similar treatment is applied to the operated-on eye, and the dressings should always be carefully examined for signs of discharge or bleeding. Both eyes are dressed as before and bandaged up.

In an uncomplicated case, the eyes are dressed in the same manner every day, or less frequently if the patient suffers no discomfort or pain. At the end of the fourth day, the bandage may be left off the sound eye, but it is usual to keep the eye, which has been operated on, bandaged up for a week at least.

The patient must be told to lie, if possible, on his back for forty-eight hours, and then he may turn a little over to the sound side. For the first forty-eight hours he should be watched day and night, and it is a very good plan to restrict his hands by tying them down when he is going to sleep, as the success of many an operation has been marred by an involuntary blow from the patient's hand.

In cases without iridectomy, in order to keep the eye as completely at rest as possible, I often strap or plaster up the operated-on eye, and do not look at the eye for four or five days, unless the patient has pain. If there is any doubt about the position of the pupil after the operation, it is best to dress the case the same evening, and then, if all is quiet, to strap the eye up. When the wound is quite healed it is advisable to use atropine drops once or twice, to make sure that the pupil will dilate, and is not bound down to the remains of capsule.

Some operators use atropine as a routine treatment in nearly every case after extraction.

The objection to atropine drops, when iridectomy has been performed, is that the dilatation of the pupil prevents the coloboma being kept small, and may induce traction on the ciliary region. Atropine irritation and conjunctivitis may also be set up.

For the first two or three days, the diet should consist of fluids and soft foods that do not necessitate much muscular effort in mastication.

The patient must avoid all straining, and must on no

account leave his bed until the wound is healed. As ligh irritates the eyes, the patient should not be placed facing it, and the room should be kept moderately dark.

After the wound is well healed, and any inflammatory symptoms have disappeared, the patient may be allowed to go out, but should wear goggles or tinted glasses for a time.

If the removal of the lens is quite successful, the patient should be tried for glasses in about two months, as it requires fully that time for the eye to quiet down, and for the cornea to assume its new shape.

It is usual to order a glass for distance, and a stronger one for reading, and if the non-operated-on eye has little power of vision, it is useful to order the glasses in a reversible frame, so that the distance glass may be over the other eye when the operated-on eye is used for reading, and *vice versâ*. This does away with the necessity for two pairs of spectacles. The changes in the cornea often produce astigmatism. The strength of glasses to be prescribed will be found under 'Aphakia' (p. 384). It is important to warn patients that with glasses they will, at first, experience considerable difficulty in judging distance, as going up and down stairs. The vision corrected with glasses may be $\frac{6}{6}$ and ·5 at 20 cm., and is frequently $\frac{6}{12}$; some patients from nervousness do not see well at first, but improve after a time. An operation is said to be a success when with glasses the vision is at least $\frac{6}{36}$, a partial success when the vision is less than $\frac{6}{60}$ and at least large objects, and a failure if there is only perception of light.

Immediate complications.—If the operation has been a difficult one, there may be pain, swelling of the lids, and congestion and chemosis of the conjunctiva the next day; these symptoms may disappear on the application of leeches, and the administration of quinine internally. The wound may not heal for some days, owing to the state of the patient's general health, or to the presence of lens

débris or iris tissue in the incision; occasionally there may be a leakage from the wound preventing the formation of the anterior chamber for weeks. These conditions are best treated by compresses and firm bandaging, or sometimes by cauterisation of the wound.

Wound infection may occur about twenty-four hours after the operation, and is rare after the fourth day. The signs are generally ushered in by great pain in the eye, accompanied by a flow of scalding tears, which prevents the patient sleeping; occasionally, and it is a bad symptom, there may be no pain.

The signs are congestion and chemosis of the conjunctiva, and the edges of the wound look white or yellowish. A muco-purulent or purulent discharge soon ensues, and, unless checked, the eye may pass into the condition of panophthalmitis. This occurs generally in broken-down subjects, but can usually be traced to introduction of septic material into the eye during the operation. The treatment is cauterisation of the lips of the wound, the use of antiseptic lotions, as nitrate of silver (F. 35) or perchloride of mercury (F. 34), and fomentations of belladonna (F. 4) or poppyheads (F. 39). The patient's general health should be kept up by stimulants and good feeding: quinine is generally indicated, and also hypodermic injections of morphia to allay the pain.

The cornea is sometimes affected, probably owing to infiltration from the wound, or from cocaine especially if perchloride of mercury has been used. It may be simply dulled for some days, the superficial epithelium may be denuded in places, or it may have a striped appearance (*striped keratitis*).

Prolapse of iris happens, as a rule, about twenty-four hours after the operation, but may occur as late as the fifth day. It is generally met with in cases without iridectomy, and the first symptoms are sudden, sharp, shooting pain in the eye, followed by profuse watery

discharge. The cause may be due to the irritation and swelling of softened lens matter, or to a sudden shock or strain as cough or vomiting. If the prolapse of iris is recent it may be replaced by a spatula and kept in its place by eserine; but, as a rule, it must be cut off. Firm bandaging may be tried, but the prolapse if left generally gives rise to a *cystoid cicatrix,* which should be cauterised or tapped, and the eye then firmly bandaged.

The effect of prolapse of the iris is to draw the pupillary aperture towards the wound, and in some cases to close the pupil.

Iritis is the most common complication, and must be treated by atropine and fomentations. It is not serious unless there is much effusion of lymph, or *cyclitis* is also present.

Hyphæma may occur some days after the operation, and may disappear and recur several times; the eye should be bandaged and the iris kept at rest by atropine.

Glaucoma may occur directly the wound has closed, but generally some months afterwards; it is sometimes set up by needling operations. It is due to the iris or ciliary processes being caught in the scar tissue, and thus causing obstruction at the iridic angle.

Subretinal hæmorrhage is occasionally met with, being ushered in by sharp pain in the eye followed by a gush of vitreous and profuse hæmorrhage, and results from the effect of the sudden diminution of pressure on diseased vessels.

Remote complications.—*Sympathetic ophthalmitis* is a very rare sequela. *Erythropsia,* or red vision, may occur after some months, lasting a short or long time; visual acuity is not affected, and the symptom does not call for treatment. Owing to the changes in the cornea, *astigmatism* may be produced, and the vision in many cases of extraction is much improved by the addition of a weak cylinder to the convex glasses ordered.

It is not uncommon in cases of successful extraction, in which the vision after operation has been good, for the sight to deteriorate after some months or even years. This may be due to thickening of the capsule, or changes in the vitreous, choroid, or retina.

After-cataract is the name applied to the remains of capsule, lens matter, or products of inflammation, found in the coloboma or pupil after an operation for cataract. Clinically, they may be divided into two classes—non-inflammatory and inflammatory.

1. The *non-inflammatory*, generally seen as fine cracks and lines in the pupillary area, are not adherent to the iris, and therefore do not interfere with the action of the pupil. They consist of remains of the anterior capsule or lens substance, and also of the opaque posterior capsule; they may not appear for months after the extraction. They generally produce considerable loss of vision, and are easily treated under cocaine by breaking them up by means of a needle (fig. 54) introduced through the corneal periphery. Occasionally, it is advisable to employ a second needle passed from the opposite side, so that the capsule can be torn between them.

2. The *inflammatory* cases are much more serious, and are the result of iritis or cyclitis. They consist of a more or less thick membrane occluding the pupil and bound down to the iris. The treatment in these cases must be put off till all signs of active inflammation have disappeared. Needles should never be used to tear these membranes; and the best way is to introduce a thin Graefe's knife near the periphery of the cornea into the anterior chamber, and when the point of the knife has reached the limit of the proposed coloboma, the handle should be raised, and the knife made to cut its way through the iris and membrane as far as desired, and then slowly withdrawn. Sometimes an iridectomy is the best treatment.

Operations on after-cataracts, though sometimes easy, are always to be undertaken with great caution, as cyclitis, glaucoma, and even panophthalmitis, may be set up.

Aphakia (ἀ, not; φακός, lentil) is the term applied to the condition of the eye when the lens has been removed from the line of vision by operation, absorption after injury, or by dislocation. In these cases the anterior chamber is deep, the iris generally tremulous, and the reflexes seen normally at the anterior and posterior surfaces of the lens are absent. The eye is in a state of hypermetropia, and there is no power of accommodation. It is necessary to give a convex glass for distance, and a stronger one for reading (see page 384).

Dislocation of the lens may be traumatic, or congenital, complete or partial; if complete, it is into the aqueous or vitreous chambers.

The *symptoms* are chiefly those of disturbance of vision, such as monocular diplopia and defective accommodation, and there may be great neuralgic pain. A constant sign is a tremulous condition of the iris.

In the *complete* variety the anterior chamber is deep, the two lenticular reflexes are absent, and there is no power of accommodation. When the dislocation is into the aqueous chamber, the lens, if of normal structure, looks by oblique illumination like a drop of oil with a golden margin.

When it is into the vitreous chamber, the lens lies at the lowest part; in either case the lens soon becomes opaque. In traumatic cases complicated with rupture of the sclerotic the lens may lie beneath the conjunctiva.

In *partial* dislocations, a black line may be seen in some part of the pupillary area corresponding to the rounded edge of the lens, and in some cases, by the indirect ophthalmoscopic examination, the optic disc may appear doubled, in consequence of the fundus being seen

through the lens and also through the portion of the pupil unoccupied by it.

The tremulousness of the iris is best seen near the dislocated portion, and immediately opposite this place the iris is pushed forwards rendering the anterior chamber more shallow.

Complications and sequelæ.—Irido-cyclitis and choroiditis are sometimes associated with, or follow, backward displacements of the lens; inflammation of the cornea and secondary glaucoma not unfrequently result from forward dislocations.

Causation.—Displacements of the lens are congenital or acquired, and result from some defect in the suspensory ligament, as rupture, stretching, or imperfect development. The congenital variety occurs in both eyes, and is often hereditary; the acquired form is caused by a blow on the head or eye, or by strain, as coughing or vomiting.

The *treatment* of dislocation into the aqueous chamber is to remove the lens. In young subjects this may be done by discission, but in other cases extraction by a corneal flap must be employed. The lens should first be fixed by a needle to keep it in position, as otherwise it would dislocate into the vitreous chamber. After the corneal incision the lens should be delivered by a spoon or vectis. No operative procedures for removal of the lens are of avail in dislocation into the vitreous chamber, and the lens may occasionally lie there for years without exciting any marked inflammation, the eye being in the same condition as after the old operation of couching. Glasses should be ordered as in a case of aphakia.

In partial dislocation, owing to the alteration in refraction, glasses may improve the vision. In cases where the edge of the partially dislocated lens divides the pupil into two parts, a convex glass correcting the refraction of the aphakic portion may greatly improve vision.

INJURIES.—The lens may be dislocated or a cataract may be produced by blows on the eye. Penetrating wounds of the eyeball, complicated with injury to the lens, are very serious owing to the lens swelling and pressing on the ciliary processes.

CHAPTER XVI

DISEASES OF THE AQUEOUS AND VITREOUS

Anatomy.—The two chambers (aqueous and vitreous) of the eyeball (fig. 64), which support the iris, lens, and retina, are two spaces or reservoirs containing modified lymph. The pressure in both is equal at all times, owing to the free communication and circulation of the fluid.

The aqueous chamber is bounded in front by the posterior surface of the cornea, and behind by the suspensory ligament and the anterior capsule of the lens, and has suspended in it the iris, dividing it into two portions. The anterior of these is known as the *anterior chamber*, and the other one as the *posterior chamber*, but in the normal state they are practically one, owing to the pupillary aperture.

The anterior aqueous chamber is situated between the cornea in front and the iris behind; at the junction of the latter with the cornea is the iridic or filtration angle, through which the lymph circulates, and passes by the spaces of Fontana and canal of Schlemm to the anterior ciliary veins.

The posterior aqueous chamber is triangular in section, with its greatest width near the ciliary body, and is bounded in front by the posterior surface of the iris, behind by the anterior capsule and suspensory ligament of the lens, and peripherally by the ciliary body.

The aqueous humour is a fluid of low specific gravity, containing water, a few salts, and a very small quantity

of albumen. The fluid differs from ordinary lymph, resembling rather the cerebro-spinal fluid; it is secreted by the ciliary processes, and perhaps by the iris (in cases of aniridia it is normal). It mainly passes from the ciliary processes in front of the suspensory ligament of the lens into the posterior aqueous chamber. Its secretion is very

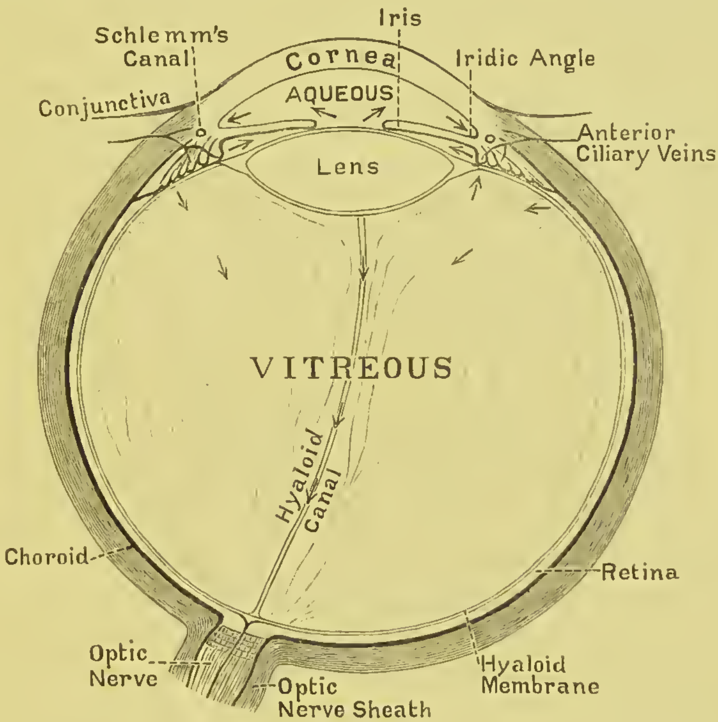


FIG 64.—DIAGRAM SHOWING THE CIRCULATION OF THE INTRA-OCULAR FLUID

rapid, as can be demonstrated by tapping the anterior chamber, when in a few minutes the chamber is reformed.

In fœtal life the anterior chamber for some time is absent, and in consequence the iris and lens lie in close apposition to the cornea.

The vitreous or posterior of the two main chambers is filled with a thin gelatinous transparent tissue (mucoid

tissue), and may be compared to a sponge permeated with a watery fluid of about the same specific gravity as the aqueous. The vitreous is arranged in concentric lamellæ, which can be demonstrated after hardening with chromic acid, and is a remnant of fœtal mesoblastic structure containing a few stellate and fusiform cells, and numerous fibrillæ. This gelatinous tissue is never reformed when the vitreous is lost by operation or injury; in such cases, the chamber is refilled by the watery secretion from the ciliary processes. The new condition is known as *fluid* vitreous, and owing to the alteration and consequent want of proper support, the iris and lens generally become tremulous. The vitreous fluid is enclosed by a thin homogeneous structure known as the *hyaloid membrane*, which is intimately attached to the internal limiting membrane of the retina, and in front, leaving the ciliary processes, adheres to the suspensory ligament. This membrane allows the watery fluid to filter through it.

The fluid of the vitreous is secreted by the ciliary processes, and most of it finds its way through the suspensory ligament into the aqueous chamber; but a small quantity passes by the hyaloid canal to the optic nerve sheath, and also by the supra-choroidal tract to the pial sheath of the nerve. The vitreous is an avascular structure, but in fœtal life it contains blood vessels passing from the central artery of the retina to the posterior surface of the capsule of the lens, and forming a plexus of blood vessels for the nutrition of the lens. The canal through which this hyaloid artery passes is known as the *hyaloid canal*, and after fœtal life, though as a rule invisible, it conducts the circulating lymph to the optic nerve.

Circulation of the intra-ocular fluids (fig. 64).—In a healthy eye, there is always a circulation taking place of the fluid secreted by the ciliary processes, which keeps the vitreous and aqueous chambers in a state of distention. The circulation is determined by the blood

flow, and the intra-ocular pressure varies with the blood pressure.

The fluid passes in two main directions: (1) through the suspensory ligament and hyaloid membrane into the vitreous, and (2) directly into the posterior portion of the aqueous chamber. The vitreous portion flows mainly through the suspensory ligament into the anterior chamber, but some circulates along the hyaloid canal to the optic nerve, and thus through the nerve sheath to the cerebro-spinal fluid.

The direction of the circulation of the aqueous portion is from the posterior aqueous chamber through the pupillary aperture into the anterior part of that chamber, and then towards its periphery, passing through the iridic or filtration angle into the spaces of Fontana and canal of Schlemm, and so to the anterior ciliary veins.

Diseases of the Aqueous

The **aqueous chamber** varies greatly in depth even in health, and becomes more shallow during the action of accommodation and in old people; it is deeper in myopes than in hypermetropes. It increases in depth owing to exaggerated curvature of the cornea, as in staphyloma and conical cornea, or from recession of the lens and iris in aphakia, cyclitis, and iritis. It is diminished by the advance of the iris and lens in glaucoma and intra-ocular tumour, or by flattening of the cornea.

In certain diseases, as iritis, uveitis especially sympathetic, and glaucoma, the aqueous may become turbid and more albuminous.

Hyphæma (ὑπό, under; αἷμα, blood), or blood in the anterior chamber, can be diagnosed by its black or bright red appearance. In some cases the chamber may be quite full of blood, but as a rule it is seen only in the most dependent part (fig. 65), and has either a straight or

slightly concave upper border. As a rule the blood is quickly absorbed, but may remain for several weeks.

The hyphæma changes its place when the head remains long in one position. Vision is generally much reduced, and there may be a recurrence of the hæmorrhage.

It may be produced spontaneously, but generally is due to traumatism following a blow on the eye or on the head, and it also occurs after operations on the iris.

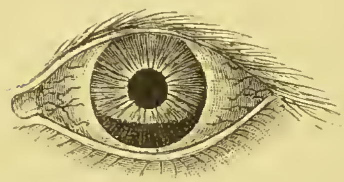


FIG. 65.—HYPHÆMA

The *treatment* is by application of ice-cold compresses or hot fomentations, tight bandaging, and sometimes the application of atropine.

Hypopyon (*ὑπό*, under; *πύον*, pus) is the term applied to pus or lymph in the anterior chamber. It is generally found in the lowest part (fig. 21), and may be fluid, moving with the position of the head, or viscid, resembling organised lymph. It is a symptom of purulent cyclitis, and usually follows an infective corneal ulcer (p. 76). In children it is not such a serious symptom, and quickly disappears on treatment; but in adults it is much more dangerous.

Treatment.—In children, belladonna fomentations and atropine drops to dilate the pupil; in adults, it is often necessary to perform paracentesis of the anterior chamber (p. 81) in order to evacuate the pus.

A dislocated lens or a cysticercus may be occasionally found in the anterior chamber.

Foreign bodies find their way into the anterior chamber occasionally through the sclerotic, but as a rule through the cornea. In all such cases, therefore, the cornea should be very carefully examined for a scar. Unless entangled in the iris, they are found at the lowest part of the chamber and generally give rise to ciliary congestion and

pain, though if not removed, a foreign body may become encapsuled, and remain for years without giving rise to any further trouble. The complications are mostly due to septic condition of the foreign body, and may be iritis, cyclitis, and even purulent uveitis. The foreign bodies comprise eyelashes, gun caps, glass, and pieces of metal as steel (heated metal is aseptic). With the exception of glass, they can generally be seen by focal illumination, unless they are concealed by the presence of blood, or entangled in the iris.

The *treatment* is to extract the foreign body, if possible; when of iron or steel it may be removed by a magnet introduced through a corneal incision. In other cases, after a corneal incision, it should be seized with a pair of small forceps. These operations should always be done under an anæsthetic, as it is most important that the patient should be kept quiet.

Diseases of the Vitreous

Congenital abnormalities.—*Persistence of the hyaloid artery* is occasionally met with, and is seen by the ophthalmoscope as a tortuous, cord-like vessel containing blood and coming forward from the optic disc into the vitreous. In other cases, the hyaloid canal may be seen as a small greyish-white *cul-de-sac* near the disc.

Fibrous membranes [1] are found, especially in cases of congenital cataract, behind the lens, and are the remains of the hyaloid artery or the fibro-vascular sheath at the back of the lens.

Muscæ volitantes (*musca*, a fly; *volitans*, flitting) is the term used for the appearance of motes floating before the eyes without any obvious structural changes in the vitreous or in the other transparent media. These are observed most distinctly in bright lights, especially

[1] Collins, *Anatomy and Pathology of the Eye*, p. 41.

when gazing at a plain surface, such as the blue of the sky, or on looking through a microscope. They are grey in colour, and take the form of twisted strings of pearly globules, hair-like opacities, and single globules. Mucus on the cornea, notably in cases with conjunctival discharge, is often mistaken for muscæ, but the appearance vanishes on rubbing the lid over the cornea.

These motes are produced by the shadows thrown on the retina by the cells normally found in the vitreous, and are frequently seen in cases of refraction errors, as myopia, and in patients suffering from digestion troubles. They give rise to a good deal of annoyance, but do not affect the acuity of vision, and are present in every adult at times. A good way to observe them is to look at the sky through a pinhole in a card.

The treatment, if they are of recent origin, is to attend to the general health, and a blue pill will often relieve the symptoms; but if of long standing, active measures are of little avail. The patient should be told to try to forget their presence, which is largely due to his looking for and expecting to see them. In very troublesome cases, the eye should be rested from work as much as possible, and the use of tinted glasses advised.

Synchysis (σύν, with; χέω, I pour) (*fluid vitreous*) is the condition in which the vitreous has lost its gelatinous consistency. It is found after perforating wounds and operations attended by loss of vitreous, and in cases of staphyloma and uveitis; it is diagnosed by the rapid movement of the opacities in the vitreous, and, as a rule, by a tremulous condition of the iris. Though generally associated with diminution of tension, it may be found with normal or even increased tension.

Vitreous opacities.—As a result of morbid changes in the vitreous and the surrounding structures (ciliary body, choroid, and retina), opacities of various shapes and sizes make their appearance in the vitreous chamber.

The symptoms are chiefly those of disturbance of vision, which may be greatly impaired according to the number and size of the opacities, the patient complaining of the appearance of objects floating before the eye. When only one opacity is present, the patient will accurately describe its shape, and from its movement being limited to a portion of the vitreous, he will be able to bring it into the field by a particular movement of the eye.

Signs.—The methods of exploring the vitreous by the ophthalmoscope have already been described on pp. 19, 21. The opacities appear as dark objects moving in front of the red reflex of the fundus, and on examining their details by the direct close ophthalmoscopic method, the following clinical varieties may be distinguished :—

(1) *Isolated dots*, most numerous at the anterior and posterior parts of the vitreous, seen in cyclitis and myopia.

(2) *Dust-like clouds*, of which the elements may be too minute to be separately distinguished. These are found in limited portions of the vitreous, and are characteristic of syphilitic affections of the retina and choroid.

(3) *Membranous patches*, like black crape or muslin, usually the result of extensive hæmorrhages.

(4) *Beads, strings, or threads.*

(5) *Minute glittering scales* of cholesterine, resembling flakes of snow falling past a lighted street lamp, and known as *synchysis scintillans.* These are met with generally in old people, may not interfere with vision, and are the result of degenerative changes.

The view of the fundus is obscured according to the number and size of the opacities, and in some cases the disc has a pink hyperæmic look, owing to the altered condition of the vitreous.

Causation.—They may follow injury to the eye, and are then due to hæmorrhage from the choroidal or retinal vessels, but most commonly are the result of disease of the surrounding structures. The ocular diseases in which

they are found are cyclitis, uveitis, retinitis, choroiditis, and myopia, and they are associated with gout, malarial fever, influenza, anæmia, and menstrual troubles.

The prognosis is favourable in the early stages of syphilis, and in some cases of hæmorrhage. The progress is often slow, and sometimes the opacities are permanent.

The treatment varies with the cause; mercury and iodide of potassium are perhaps the most useful drugs. The local treatment is rest for the eyes and the use of tinted glasses.

Hæmorrhages in the vitreous.—*The symptoms* are the same as those of vitreous opacities, but when the whole vitreous is suffused with blood the blindness may be nearly complete. *The signs* are presence of vitreous opacities; the hæmorrhage can sometimes be seen of a red colour by the ophthalmoscope and by oblique illumination, but occasionally no red reflex can be seen, the pupillary area appearing black. They may persist for some months, but generally become absorbed. In old people they follow any severe effort or strain, and are associated with gout and diabetes. There is a class of cases occurring in young adults (females or weakly males) in which the bleeding is profuse, and tends to recur.

Other causes are diminution of intra-ocular tension, a blow on the eye, or they may follow an operation, as for cataract.

The blood generally comes from the choroidal vessels, and, except in traumatic cases, the exciting cause is a strain, as cough, constipation, &c.

The treatment is absolute rest with the eyes bandaged, and avoidance of strain or stooping. Iced compresses may be used, and the general health, especially the heart and kidneys, must be carefully investigated.

New blood vessels are occasionally found in the vitreous, proceeding from the retinal vessels. They probably follow a hæmorrhage into the deeper parts of the

vitreous, to which new vessels proceed, and as these grow forwards they become very convoluted, and often have the appearance of a tassel; parallactic movement is generally present. In many cases there is a history of syphilis.

New connective tissue, frequently accompanied by blood vessels, and protruding into the vitreous, is also met with near the disc; the condition described as *retinitis proliferans* probably belongs to this class of cases.

Cords of fibrous tissue may be seen passing across the vitreous in cases of detachment of the retina, of which probably they are the active cause.

Suppuration in the vitreous is characterised by the presence of a yellowish mass, which may be mistaken for glioma, and is known as *pseudo-glioma*. It is frequently the result of a perforating wound of the eye, especially if complicated by a foreign body in the vitreous, but may occur in young children from choroidal inflammation (p. 147) due to tubercle or syphilis. It is frequently followed by panophthalmitis and shrinking of the eyeball.

Detachment of the vitreous occurs in cases of high myopia from the effect of a blow, but there are no certain methods of diagnosis.

A dislocated lens or a cysticercus are occasionally seen in the vitreous.

FIG. 66.—ELECTRO-MAGNET

Foreign bodies.—If a piece of metal or glass perforate the cornea or sclerotic with great force, it may pass into the vitreous. When the eye is examined by the ophthalmoscope soon after the injury the foreign body may be seen lying, as a rule, in the lower part of the vitreous chamber, but frequently the presence of

hæmorrhage or an opaque lens prevents it from being seen.

In some cases, the foreign body becomes encysted, and may remain for years without giving rise to irritation. As a rule, if not removed it produces inflammatory symptoms, as choroiditis, uveitis, panophthalmitis, and even sympathetic ophthalmitis.

Treatment.—If the foreign body be iron or steel, it may be removed by the electromagnet (fig. 66). The terminal of the magnet is passed through the wound in the sclerotic, or through a meridional incision in that structure made by a keratome, and is moved about gently in the vitreous until the foreign body adheres to the magnet, and is withdrawn. The conjunctiva should be stitched over the wound, and in some cases the sclerotic should also be sutured.

If the magnet cannot be employed, a pair of forceps may be used to extract the foreign body. The ophthalmoscope is of great assistance in enabling the surgeon to observe the steps of the operation.

CHAPTER XVII

GLAUCOMA

GLAUCOMA (γλαυκὸς, sea-green) is one of the most important diseases of the eye, owing to its serious nature, the difficulty experienced in its treatment, and the certain result of complete blindness if left untreated.

The chief characteristic is the increase of intra-ocular tension at some period in its course, and this in common with the other symptoms is as a rule intermittent.

Glaucoma may be divided into *primary*, consisting of those cases in which no previous disease of the eye can be found as a cause; and *secondary*, those resulting from some other ocular disease or injury.

It is essentially a disease of late middle life, and is rarely seen before the age of forty-five, except in the secondary form.

Primary glaucoma.—There are two well-marked classes: *congestive* or *inflammatory*, which may be acute or chronic, and in which there are distinct vascular changes; and *simple*, in which all such signs are absent.

Most of the following signs and symptoms are found during the progress of a case of primary glaucoma, and these are generally ushered in by premonitory symptoms, which may last for some months or years before the actual attack.

Premonitory symptoms consist of :—*Rapidly increasing*

presbyopia, which necessitates very frequent change of glasses for reading.

Obscurations of vision, during which everything appears as in a yellowish fog.

Rainbow colours seen at times as circular rings round candles and lamps. The rings are generally two broad bands, the one next the light being bluish green and the external one red; frequently there is reduplication of the rings, four being visible.

The appearance of these coloured rings is not confined to cases of glaucoma, as they are found in patients suffering from conjunctival discharge, and also in normal eyes if the pupils are dilated. The glaucomatous rings, however, are much more vivid, and patients often complain of being blinded by them. They are produced by changes in the cornea, probably of an œdematous nature.

These symptoms are accompanied at times by increased intra-ocular tension and diminution of the acuity of vision for distance, and are chiefly found when the patient is over-tired, or suffering from want of food or sleep. They last generally only a short time, being relieved by rest, warmth and proper nourishment, and the eye for a time becomes normal, but they return at intervals, during even a year or two, until some day an acute attack of glaucoma supervenes.

Either with or without marked premonitory symptoms, the eye passes into a glaucomatous state.

Symptoms and signs of glaucoma.—*Diminution of acuity* of vision for distance.

Rapidly increasing presbyopia, necessitating too frequent change of glasses for reading, from paresis of the ciliary muscle owing to pressure on its nerves, and perhaps to stretching of the choroid.

Contraction of the field of vision is probably the first symptom, and may occur before there is any alteration in distant vision. It is therefore most important that the

field (fig. 67) should be taken in every case of suspected glaucoma. It is contracted at first on the nasal side, sometimes a considerable sector being absent; the tendency is for it to become more contracted at the periphery, and the fixation point may even be reached at the nasal side. The field for colours is, as a rule, concentrically contracted.

Diminution of light sense is generally to be found, though central colour vision may be normal.

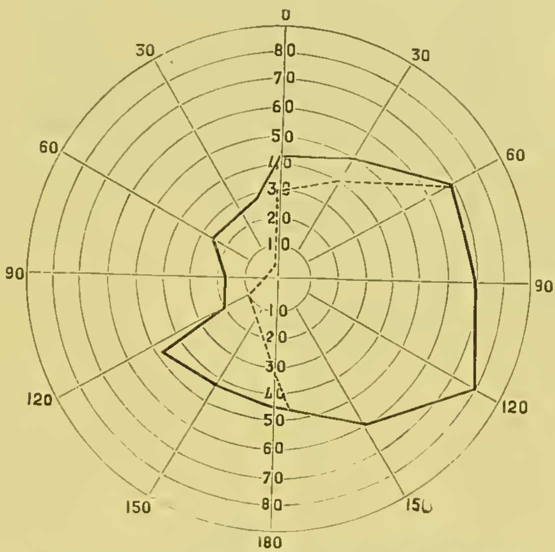


Fig. 67.—Right Visual Field in Case of Simple Glaucoma, showing Contraction, most marked at Nasal Side. The Dotted Line shows the further Contraction a Month after the First Field, indicated by the Black Line, was taken

Sensation of bright lights (photopsia) is frequently complained of, and is due to irritation of the retina by the increased tension and vascular change.

Pain is present at some time during an attack, either in the eye or as acute neuralgia along the distribution of the fifth nerve, especially the supra-orbital and nasal branches of the ophthalmic division. There is also frequently *tenderness* about the supra-orbital notch.

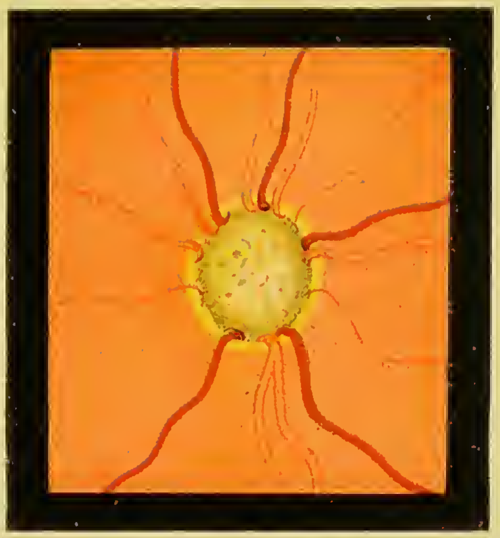
Increase of intra-ocular tension is invariably present, though in some cases it is transitory and intermittent and hence difficult to find; it is frequently present during sleep. The method of estimating intra-ocular tension is by palpating the eyeball through the closed lids by both index fingers, as already described on p. 5. Any degree of increased tension (+ 1, + 2, + 3) may be present in glaucoma, and the higher the amount the more severe the case. As a rule, in acute congestive glaucoma the tension is highest (+2, +3); in the chronic forms it may be scarcely raised at all or +1.

The cupping of the optic disc (Plate IV. *a*) varies greatly in degree, and is produced by the optic papilla, with the lamina cribrosa and the retinal vessels, being pushed backwards (fig. 10, C), owing to the increased intra-ocular pressure, and partly perhaps to atrophy. The cupping tends to involve the whole surface of the disc, and the retinal vessels appear to come from the periphery instead of from near the centre. The scleral ring is often undermined, the vessels being seen to curl round and disappear at its edge. The floor of the cup is white, with sometimes a green or blue tinge. The disc is surrounded by a white or pale yellow ring resulting from atrophy of the choroid.

The cup can be best examined by the direct ophthalmoscopic method, and parallactic movements are seen on moving the mirror. Its depth may be estimated by observing the difference between the lens necessary to see distinctly a vessel at the margin of the disc and one at the base of the excavation, and is generally at least six dioptres, which correspond to 2 mm. of cupping (3 dioptres equal 1 mm.) By the indirect method the parallax is also easily obtained on moving the objective lens from side to side or from above downwards.

Obstruction of the retinal circulation is shown by pulsation along the course of the retinal arteries starting from the disc, and engorgement of the veins. Pulsation

a



GLAUCOMA.

b

MYOPIC CRESCENT.

in the veins is generally present, but this sign is in no way distinctive, as it so often exists in the normal eye.

Dilatation of the pupil is a constant sign, the shape being frequently oval. At first the pupillary reflexes are normal, but as the disease advances the pupil becomes still more dilated, the reflexes much lessened and at last absent.

The pupil often presents a greenish appearance, which is due to the reflection of too much light from the lens, and also to the turbidity of the aqueous and haziness of the cornea.

Steaminess of the cornea is most marked near its centre, and the whole cornea may present a roughened and pitted appearance.

Anæsthesia of the cornea to a greater or less extent is generally found, from the œdema of the cornea compressing the endings of the nerves.

External vascular changes are seen, as congestion and dilatation of the episcleral vessels, produced partly from obstruction of the venæ vorticosæ.

Shallow anterior chamber from pressing forwards of the iris and lens is a valuable sign, but occasionally, as in the young, the chamber may be deep.

Acute congestive glaucoma is characterised by the severity and suddenness of the onset.

The patient has usually suffered from the characteristic prodromata, rapidly increasing presbyopia, obscurations and fogginess of vision, and rainbow halos, for some time. Suddenly, he is seized with great pain in the eye, accompanied by severe neuralgia and vomiting. This frequently occurs during the night, and has been mistaken for a bilious attack.

Symptoms.—There is severe pain in the orbit and eye, radiating along all the nerves in the neighbourhood, and often affecting the whole side of the head; the vision is greatly reduced, even to loss of perception of light.

Signs.—The eyelids are swollen and red; the conjunctival and episcleral vessels are much congested; photophobia and lachrymation are present, and the conjunctivæ are chemosed.

Steaminess of the cornea prevents, as a rule, any clear view of the fundus being obtained; even the red reflex being rendered dark grey.

The anterior chamber is shallow; the pupil widely dilated, not quite circular, and acting very slightly, or not at all, to the reflexes.

If the fundus can be observed by the ophthalmoscope there will be marked pulsation of the retinal arteries and great engorgement of the retinal veins; the optic disc is, as a rule, not cupped in a first attack of acute glaucoma unless there has been a previous glaucomatous condition. The tension is much increased, and may be + 3. Such an attack, unless there have been several previous ones, will pass off after a few days, but is generally followed by others at intervals.

A first attack of acute glaucoma rarely destroys permanently the vision, which gradually returns; there is generally a partial loss of the field of vision, especially at the nasal side. After two or three attacks, the eye may remain in a chronic state of glaucoma, but in some cases it passes into the state of glaucoma absolutum.

Glaucoma absolutum is the name given to the condition of the eye when it is in a permanent state of glaucoma, the tension being much raised, the vision reduced to 'no perception of light,' and, as a rule, the eye itself being excessively painful. The eye has a blind appearance, the episcleral and perforating vessels are markedly enlarged; the sclerotic is discoloured and at times bulging; the cornea is anæsthetic, hazy, and its anterior epithelium roughened; the anterior chamber is shallow; the iris discoloured; the pupil widely dilated, fixed, and of a greenish hue; the

lens hazy and sometimes opaque. With the ophthalmoscope, the red reflex appears dulled, and no details are to be made out in the fundus. There are generally intra-ocular hæmorrhages, especially in the retina, and the optic nerve will be found to be deeply cupped. In many cases, after a time, the cornea becomes ulcerated and staphylomatous; if perforation occurs, the eye may pass into a state of panophthalmitis, and in all cases becomes atrophied.

Chronic congestive glaucoma may follow the acute form, but generally occurs without any acute symptoms. Its course is gradual, and interrupted by attacks of greater severity, which may sometimes, though rarely, assume the acute form. Both eyes are as a rule affected, but one usually before the other.

The symptoms are dull peri-orbital pain, neuralgia along the supra-orbital and nasal nerves, and headache. The patient complains of a heaviness and feeling of tension in the eyes. Obscuration of vision at times, rapidly increasing presbyopia and loss of vision, rainbow halos round lights, and contraction of the field of vision, are usual accompaniments.

Signs.—Except in the sub-acute attack, there is no marked congestion of the lids or conjunctiva. The perforating vessels are, as a rule, tortuous and dilated; the sclerotic has a dull look; the cornea is opalescent and steamy looking, with the epithelium roughened and pitted, in places it is anæsthetic; the anterior chamber is shallow; the iris after a time is atrophied; the pupil is dilated and frequently of different size to its fellow. With the ophthalmoscope, unless the cornea or lens be non-transparent, the fundus shows marked glaucomatous cupping of the optic papilla. There is usually arterial pulsation, and in cases in which it is not spontaneously present, it can be elicited by pressing gently on the eyeball. The intra-ocular tension may remain raised (about + 1), ut more often is found to be normal.

Simple glaucoma includes those cases in which the disease often progresses in an insidious manner without pain or evidence of congestion. With the naked eye, no signs of the disease can be seen with the exception of slight undue tortuosity of the perforating vessels. The cornea may present a normal appearance, though perhaps with diminished sensibility. The anterior chamber may be slightly shallower than usual, and the pupils sluggish and dilated, one often larger than the other. The most important sign, and frequently the only one, is the deep excavation of the optic discs, which are, as a rule, white and atrophied-looking.

Increase of tension is present only at intervals, and is therefore difficult to detect.

The symptoms are gradual diminution of central vision, and, at the same time, contraction of the field of vision, especially at the nasal side.

The disease attacks both eyes, and progresses gradually to absolute blindness.

Etiology.—Primary glaucoma has been aptly compared by Critchett to a hernia, which may last for months or years without producing any great discomfort or serious symptoms, and which may suddenly become strangulated. In glaucoma, as in strangulated hernia, there are structural and other predisposing causes for the attack. The exciting cause is usually obstruction to the circulation, and any inflammation is generally secondary to this congestion.

In the normal eye there is a mean kept up between the secretion and excretion of the fluids. The tension in the aqueous and vitreous chambers is always equal, as they are only separated by a movable curtain formed by the lens, ciliary processes, and suspensory ligament; this last being porous allows the free transmission of the fluids.

Any loss of balance between secretion and excretion will cause either an excess or a diminution in the amount of fluid contained in the eye.

Glaucoma is associated with an increase of intra-ocular tension, due in primary glaucoma to an excess of fluid in the eye, and this must be produced by hyper-secretion, diminished excretion, or a combination of both.

The great difficulty in determining the initial changes in glaucoma, proceeds from the fact that eyes are never excised until the disease has lasted some time; hence it is almost impossible to distinguish which are the primary and which the secondary pathological changes.

The two chief theories for the production of glaucoma are:—(1) that it is due in the beginning to inflammatory changes; and (2) that the onset is purely mechanical and produced by pressure, any inflammatory changes being secondary.

As glaucoma exists in such different forms, and is rather a collection of symptoms than a single definite disease, it is impossible for one theory to explain every case, and there is no doubt that both these theories are in part true.

The only way to try to elucidate the causation is to consider how the most usual accompaniments of the glaucomatous condition could be produced. These include increase of intra-ocular tension, shallow anterior chamber, and advance of the lens and iris.

The subject must be considered first from a physiological point of view, and then by the aid of any constant pathological changes.

The intra-ocular fluid is secreted by the ciliary processes, and circulates in two chief directions: (1) by the posterior aqueous chamber, through the pupillary aperture, into the anterior aqueous chamber, whence it passes to the iridic angle, and so to the spaces of Fontana, canal of Schlemm, and anterior ciliary veins; and (2) into the vitreous chamber, and thence through the suspensory ligament of the lens to the posterior aqueous chamber, and then by the same course as the former to the

anterior ciliary veins. A little fluid escapes from the vitreous chamber by the hyaloid canal communicating with the optic nerve, and also along the venæ vorticosæ.

By this, it will be seen that the main outlet for the fluids from the eye is at the iridic or filtration angle, which in the normal eye (fig. 68) is bounded in front by the sclero-corneal junction, containing the canal of Schlemm and the tendon of the ciliary muscle, and behind by the base of the iris lying in front of the ciliary processes;

Fig. 68.—Normal Iridic Angle

Fig. 69.—Iridic Angle in Acute Primary Glaucoma (*after Priestley Smith*)

Fig. 70.—Iridic Angle in Chronic Primary Glaucoma

the apex of the angle is blunt, and is more like a recess extending into the ciliary body.

The only constant pathological change found in nearly all cases of glaucoma is the obliteration of the iridic angle, as in figs. 69, 70, by the application or adhesion of the base of the iris to the posterior surface of the cornea near the sclero-corneal junction.

There are two theories as to the cause of the obliteration of this angle, the first being that it is produced mechanically by the pushing forward of the ciliary pro-

cesses, lens and iris, by pressure from behind; and the second, that glaucoma is always preceded by catarrhal inflammation of the uveal tract near the iridic angle, especially the ciliary portion, and that the swollen ciliary processes push the iris base towards the cornea, and the increased vascularity of the ciliary processes at the same time produces hyper-secretion.

From these considerations, the fact of the iridic angle being the main outlet of the intra-ocular fluids, and at the same time being found obstructed in pathological examination, leads to the suspicion that the causation of glaucoma is intimately connected with the excretory function of the eye.

The generally received theory now for the production of glaucoma is that obstruction occurs in the course of the circulation of the intra-ocular fluids, owing to which the secretion taking place from the ciliary processes is retained in the eyeball (retention theory), instead of circulating, as in the normal eye.

Hyper-secretion alone cannot explain the signs usually found in glaucoma, even when combined with the addition of excretory obstruction at the iridic angle. The balance of pressure between the vitreous and aqueous chambers being still preserved, the shallow anterior chamber found in glaucoma, from pushing forward of the lens and iris, remains unaccounted for. These signs must be due to some further obstruction occurring in the channels of communication between the vitreous and aqueous chambers.

The obstruction at the iridic angle could explain the increase of intra-ocular tension if there were hyper-secretion from the ciliary processes, or even normal secretion for a time, but it would not explain the advance of the iris and lens.

The aqueous chambers are separated from the vitreous chamber by a curtain composed of the ciliary processes,

suspensory ligament and the lens in its capsule, and, as has been said before, the intimate connection of the chambers through the suspensory ligament prevents any difference of tension being sustained in either chamber. Priestley Smith[1] has brought forward a very convincing theory that the factor most likely to produce glaucoma is obstruction of the circumlental space, and that when this space is closed, the secretion of fluid into the vitreous, being unable to pass into the anterior chamber, distends the vitreous chamber and pushes forward the curtain composed of the lens, suspensory ligament, and ciliary processes, and the iris, and by this means produces application of the iris to the cornea and obliteration of the iridic angle. He gives the growth of the lens as the chief agent in the obliteration of the circumlental space. The lens grows throughout life by additions to its exterior within the capsule, hence the circumlental space is encroached upon with age, and this may account for glaucoma being, as a rule, a disease of advanced life. Glaucoma is generally accompanied by congestion symptoms, and the engorgement of the ciliary processes would help to further obstruct the circulation.

The more frequent occurrence of the disease in hypermetropic and small ill-developed eyes can be explained by this theory, as the circumlental space is smaller in such eyes, whereas the lens is the same size as in a larger eye. Small size of the cornea is an external sign of an eye with small circumlental space.

Increased serosity of the fluids may give rise to obstruction at the iridic angle, and probably inflammation or even congestion of the ciliary glands would cause an increase of density in the ordinary watery secretion of the ciliary processes. This alteration in character of the fluid secreted from these processes is shown by the

[1] *The Pathology and Treatment of Glaucoma.* J. and A. Churchill.

albuminous state of the contents of the anterior chamber found immediately on reformation of the chamber after paracentesis.

This albuminous fluid would not circulate so well through the meshes of the suspensory ligament, and these would also tend to be closed by the *débris* of cells thrown off by the ciliary glands when in increased action.

Pathological anatomy.—The changes found are very variable and difficult to determine, owing to the fact that eyes are not excised till some time after the early symptoms have set in, and degenerative changes have taken place.

There are always signs of inflammation in the iris and ciliary body, and the blood-vessels are much dilated; in acute cases the ciliary processes are enlarged (fig. 69), but in chronic cases they are atrophied (fig. 70).

The peripheral portion of the iris is generally adherent to the posterior surface of the cornea, thus obliterating the iridic angle (figs. 69, 70). In the early stages there is thickening of the iris, which is succeeded by marked atrophy.

The sclerotic is more resistant; the corneal tissue is infiltrated with small cells, and its spaces enlarged.

The optic nerve is, as a rule, cupped, and there is increase of connective tissue with atrophy and degeneration of the nerve fibres.

The changes in the retina, choroid, &c., are very variable, and not pathognomic.

Causation.—From these considerations it is evident that there are certain predisposing factors in the production of an attack of glaucoma. These include structural peculiarities, as small size of eye; increase in size of lens, especially associated with age; refraction error, as hypermetropia, inducing congestion of the ciliary processes owing to exaggerated use of the ciliary muscle; anterior position of the ciliary body; small size of cornea; and rigid sclerotic.

The age of the patient is another predisposing cause, glaucoma being rarely met with under fifty years of age, after which the sclerotic becomes firmer, the vessels more easily congested, and the lens more bulky.

Heredity plays an important part, and the disease is said to be more common among Jews than any other race. Sex has little influence on it, but females seem to be more liable to the congestive, and males to the simple form.

The *exciting causes* are numerous, and include any sudden upset to the general system, especially congestion and flushing of the capillaries of the head and face; thus, violent anger, intense excitement, stooping over work, strain as constipation or coughing, may induce an attack. Other causes are exposure to cold, starvation, sleeplessness, worry, fatigue; it frequently occurs in patients who are the subjects of gout, the uric acid diathesis, heart disease, and pulmonary complaints. Glaucoma has been produced by the dilatation of the pupil following the administration of atropine, homatropine, cocaine, and other mydriatics. It is important in a case of glaucoma, to examine for any of these causes, as on their removal or treatment, a slight attack may be warded off.

Diagnosis.—Cases of *congestive glaucoma* have been frequently mistaken for conjunctivitis and iritis, and the treatment, generally by atropine, has induced acute glaucoma. The greenish pupillary reflex has been diagnosed as cataract and the symptoms left unrelieved.

In *simple* glaucoma the diagnosis at times is difficult, and can often only be arrived at by taking into consideration all the symptoms and signs.

The glaucomatous cup may be confounded with physiological and atrophic excavations (p. 25); but the loss of central vision, and limitation of the field of vision especially at the nasal side, would distinguish it from physiological cupping.

The ophthalmoscopic signs generally can distinguish it from atrophic cupping, and in the latter the field of vision is contracted equally and scotomata are generally present.

The *prognosis*, as far as vision is concerned, is bad in all cases in which the acuity of vision is much impaired, and it deteriorates if the disease is not treated, either gradually or quickly, and ends in absolute blindness. The fatal course may occupy any length of time, from a few minutes in acute glaucoma to several years in the chronic form.

In absolute glaucoma, there are degenerative changes in the eye which may give rise to destruction of the organ, but in ordinary cases the appearance of the eye is little affected except by change in the colour of the iris due to atrophy, dilatation of the pupil, and haziness of the lens.

The *treatment* of primary glaucoma may be divided into the operative and non-operative.

Operative treatment.—Iridectomy, which was first adopted by von Graefe in the treatment of glaucoma, is the most important of the operations, and is described on p. 121.

The chief points to be observed and practised in order to secure good results from an iridectomy are the following: the portion of iris taken away should be at least one-fifth of the whole, and the removal should be up to the ciliary attachment; the incision should be in its whole course in the sclerotic about 1·5 mm. from the apparent corneal margin, and may be effected with a broad keratome or a Graefe's knife.

The chief difficulty in operating is mainly due to the shallowness of the anterior chamber, and this may be lessened by puncturing the sclerotic posteriorly some hours before performing the iridectomy.

There is generally considerable hæmorrhage from the iris into the anterior chamber, and it is important not to apply much pressure by the curette in trying to get rid of the blood, lest the lens be made cataractous. Care must

be taken that the edges of the cut iris are not entangled in the wound.

The *after treatment* consists of firm bandaging for at least forty-eight hours.

In many cases the anterior chamber is not reformed for a week. If the eye is not securely bandaged till the anterior chamber is formed, a cystoid cicatrix may be produced, generally due to a piece of iris being caught at one extremity of the wound. Such cicatrix affords a good filtration medium, and is therefore aimed at by some operators.

The exact means by which iridectomy gives relief in glaucoma are not fully understood. It is most successful in acute glaucoma, and in cases when the iris is not atrophied. It certainly, as a rule, reduces the intra-ocular tension better, and for a longer period, than mere section of the cornea or sclerotic. It was at first taught that the formation of a scar near the iridic angle promoted filtration, hence the name *filtration scar*. The formation of scar tissue in other parts of the body certainly negatives this assumption, as from contraction the tissue would be rendered more impervious to fluids than before. We therefore have to fall back on the probability that the improvement in tension is brought about by the changes of vascularity produced by the removal of a portion of the iris.

Iridectomy is most successful in relieving symptoms and improving vision in cases of acute congestive glaucoma. In chronic congestive glaucoma, its effect in some cases is very beneficial, but it rarely does more than preserve the vision for a time. Its efficacy may be gauged by its power of reducing the tension, as if this is not relieved by the operation, the prognosis is very unfavourable. In simple glaucoma, iridectomy only stays for a time the inevitable result; sometimes, the field of vision may be slightly increased after the operation, but the

distant vision is generally rendered less good from the optical defect of the coloboma.

My own opinion in chronic glaucoma is that an iridectomy should be performed as soon as possible after the disease is recognised. The earlier it is done, the more chance there is for the non-formation of a vicious circle. I think that an operation is rarely justified before the vision is appreciably reduced, say $\frac{6}{6}$ partly, or $\frac{6}{9}$, or the field is markedly curtailed, but once these signs are present the sooner the operation is performed the better. The effect of the operation is generally to reduce distant vision from the optical defects of the coloboma, but this is compensated for by the chance of warding off for a longer time the ultimate loss of useful vision. As glaucoma is a disease intimately connected and associated with nervous irritability, the moral effect of the operation in many cases gives the patient hope, and in this way aids the treatment.

In hæmorrhagic glaucoma, iridectomy is contra-indicated owing to the danger of increased hæmorrhage from the reduction of the intra-ocular tension.

Sclerotomy.—This operation (see p. 103) was introduced to take the place of iridectomy, but is now seldom practised except in cases in which tension has occurred after iridectomy, or where iridectomy is contra-indicated as in hæmorrhagic glaucoma. The chief objection to the operation is the difficulty experienced in preventing the iris from prolapsing through the wound.

In glaucoma absolutum, and other cases in which the tension cannot be kept down, *multiple punctures* of the sclerotic relieve the pain. The best treatment in glaucoma absolutum is undoubtedly to remove the eye.

Non-operative treatment.—The local treatment is directed to removing the iris from the iridic angle by contraction of the pupil. The drugs employed are eserine and pilocarpine; of these, eserine (F. 13, 14) has the stronger action and is generally prescribed as the salicylate

or sulphate, in strength from one to two grains to the ounce. In acute glaucoma, the drops should be employed every two hours, but in the chronic forms, twice a day is generally sufficient. As the tension generally rises more at night, it is important that the drops should be applied on the patient going to bed. Eserine has no curative effect unless the pupil reacts well to it, and this is a means of demonstrating whether the iris tissue is atrophied or not. The drug may be employed for a long time without any ill effects if the solution be used fresh, but there is a tendency to the production of conjunctival irritation amounting almost to a granular condition of the lower lid.

These objections are not met with in the use of pilocarpine (F. 15, 16), but the miotic effects of the drug are not so great or so lasting.

Hypermetropic patients should always wear correcting glasses to avoid any congestion of the ciliary processes by overstrain of accommodation. Presbyopes also should never read or do close work without their glasses.

The general treatment in glaucoma is all-important, and in many cases rest in bed, warmth, and a brisk purge, followed by generous diet, relieve the symptoms in a few hours.

If the patient suffers from insomnia, sleep must be induced by morphia or other hypnotic. Many cases are of the urid acid diathesis or have a gouty history.

Secondary glaucoma comprises those cases of increased intra-ocular tension in which this sign follows some other ocular disease. Increased intra-ocular tension is the chief indication; the other symptoms and signs found in primary glaucoma are not always present, being frequently masked by the effects of the original disease.

It may follow perforating ulcer of the cornea with prolapse of the iris, uveitis, cyclitis, iritis, total posterior synechia, complete or partial dislocation of the lens and

swelling of the lens due to rupture of its capsule. The operations producing it are those of extraction of cataract, needling for soft cataract and laceration of secondary capsule. Foreign bodies in the eye and intra-ocular sarcoma may also be causes. In old people with high arterial tension a form attended by retinal hæmorrhages is met with (*hæmorrhagic glaucoma*).

The treatment depends on the primary disease.

Congenital glaucoma (Buphthalmos: *βοῦς*, a bull, *ὀφθαλμός*, eye) is a condition met with at birth, in which the eye is enlarged greatly in all its dimensions. Its progress is very slow, and its termination as a rule is complete blindness. The bulging of the eye leaves it sometimes partially uncovered by the lids. The cornea is enlarged, cloudy, more bulging than normally, the sclerotic stretched and of a bluish colour, owing to the uveal pigment showing through it. The anterior chamber is deep, the iris tremulous and much atrophied, and the pupil dilated. The intra-ocular tension is raised, and if a view of the disc can be obtained, it is found to be deeply cupped.

Occasionally the course of the disease may be stopped, but as a rule it progresses.

The iridic angle is blocked by the base of the iris adhering to the cornea. From birth there is increased intra-ocular tension, which distends the thin protective coats, and so produces the deformity. The prognosis is bad as far as vision is concerned. The disease resists all treatment, and is probably best left alone. Some cases have been relieved by iridectomy, sclerotomy, puncture of the sclerotic, or repeated paracenteses of the anterior chamber. Eserine and pilocarpine may be employed as palliative measures.

CHAPTER XVIII

DISEASES OF THE LACHRYMAL APPARATUS

Anatomy.—The lachrymal apparatus comprises the lachrymal gland with its ducts situated at the upper and outer angle of the orbit, and the drainage system placed at the inner canthus, consisting of the canaliculi, lachrymal sac and nasal duct.

Its function is to keep the eye moist by secretion of tears by the gland, and to convey them by means of the canaliculi and nasal duct to the inferior meatus of the nose.

The *lachrymal gland* is a racemose gland resembling the parotid, and is divided into two parts by a process of fascia. The superior portion is lodged in a depression of the frontal bone, and the inferior (accessory) lies close to the fornix of the conjunctiva, and can be seen on everting and raising up the upper lid. The ducts are about twelve in number, and pass through the accessory gland to open separately in a row at the fornix.

The gland secretes the tears, and this secretion is chiefly reflex, as is seen by stimulating the conjunctiva, cornea, tongue, or nose; the main efferent nerve is the lachrymal branch of the ophthalmic division of the fifth nerve.

Drainage system.—There are two lachrymal canaliculi on each side, one in the upper and one in the lower lid, and each has at its commencement a minute aperture, the *punctum lachrymale,* situated on the conjunctival margin

of the lid near the inner angle. The superior canaliculus ascends from the punctum, and then makes a sudden bend downwards and inwards to join the lachrymal sac; the inferior at first descends, and then runs inwards to open into the sac by a separate orifice close to that of the superior.

The lachrymal sac and nasal duct together form the passage by which the tears reach the nose. The sac is the dilated upper blind end of the duct, and is placed near the inner canthus, behind and above the tendo palpebrarum. The nasal duct descends from the sac downwards, backwards, and outwards in an osseous canal formed by the superior maxilla, lachrymal, and lower turbinate bones, and opens into the inferior meatus of the nose. The mucous membrane is lined by ciliated epithelium continuous with the nasal mucous membrane, and is thrown into folds or valves.

The actual method by which the tears pass into the drainage system is not known, but the caruncle probably acts as a kind of sponge, and the involuntary lid wink by the contraction of some muscular fibres near the canaliculus produces a suction action.

DISEASES OF THE LACHRYMAL GLAND.—**Inflammation of the lachrymal gland** (*Dacryo-cystitis*) is a rare affection which may be acute or chronic, and occasionally bilateral. It is characterised by a lobulated, firmly fixed swelling in the position of the lachrymal gland, limitation of the ocular movements upwards and outwards, and generally proptosis. In an *acute* case there is severe throbbing pain and marked tenderness over the swelling, with œdema of both lids, most marked at the outer part of the upper lid, and chemosis and congestion of the conjunctiva. It may terminate in suppuration or resolution. The *treatment* consists, in the acute form, of hot fomentations, leeching, and a free incision if pus is suspected. The chronic form may be treated by local

application of mercurial ointment, and by iodide of potassium and mercury given internally.

Fistula of the lachrymal gland is a very rare condition, and may follow injury or abscess. A small orifice is seen on the outer part of the lid, discharging a clear watery fluid (tears). The *treatment* consists of the application of the galvano-cautery.

Cystic dilatation of a duct of the gland is met with as a transparent swelling projecting into the upper and outer part of the conjunctival sac. The treatment consists of incision or removal of part of the wall of the cyst.

Tumours may be either *innocent* (adenoma or osteoma) or *malignant* (sarcoma or carcinoma). A tumour of the gland may be diagnosed by its position, lobulated feeling, and firm attachment to the orbit, and should always be removed.

Removal of the lachrymal gland is necessary sometimes for tumours or for profuse lachrymation, when other treatment is unavailing. Under a general anæsthetic, an incision is made with a small scalpel through the skin over the outer half of the orbit, parallel with its superior margin and just below the eyebrow. The fascia is next divided, and then the fibres of the orbicularis down to the periosteum; on now dividing the palpebral ligament the gland is seen, and should be seized with a pair of toothed forceps, drawn forwards, and dissected out. The skin is afterwards stitched up.

In cases where the operation is done for increased lachrymation the accessory portion of the gland need only be removed, and this is easily done from the conjunctival surface.

AFFECTIONS OF THE DRAINAGE SYSTEM are mainly those of obstruction or interference with the passage of tears, and may be divided into those of the puncta, canaliculi, lachrymal sac, and nasal duct.

By *epiphora* (ἐπιφορά, sudden burst of tears), or watery

eye, is understood the overflowing of the tears associated with these affections, and it is convenient and usual to apply the term *lachrymation* to the increased flow of tears present in inflammation of the conjunctiva, &c.

Epiphora is not, as a rule, caused by undue secretion of tears, but by some imperfection of the drainage system by which the outflow is retarded. The tears, being unable to escape, accumulate at the inner angle of the eye, and run over the lid margin down the cheek. Patients suffering from it generally have a tear standing in the eye. It is always increased on cold, windy days, and is generally unilateral unless there be disease of the bones of the nose, when it may be bilateral.

The *punctum* may be misplaced by eversion or inversion of the lid, or it may be obstructed or even closed as a result of inflammation, such as ciliary blepharitis, styes, &c., or by an eyelash. In elderly people it is frequently everted from want of tone of the tissues of the lid, and such displacement is found in ectropion and paralysis of the orbicularis palpebrarum muscle.

A *canaliculus*, generally the lower, may be obstructed by concretions or foreign bodies such as eyelashes, or stenosed from inflammation, wounds or burns. The common situation for a stricture of the canaliculus is at its opening into the lachrymal sac.

Occasionally there may be a congenital absence of the canaliculi and puncta, or reduplication of both.

Treatment.—When a punctum or canaliculus is obstructed by an eyelash or concretion, the foreign body may be removed with a small pair of forceps. If the punctum is very small it may be dilated by the wire gauge (fig. 71) or a small probe (fig. 72), or by electrolysis, and failing these methods it must be slit up together with the canaliculus. In the case of a misplaced punctum, if the general condition of the lid cannot be improved, the canaliculus must be slit up.

In stricture or obstruction of the canaliculus, a small probe should, if possible, be passed as far as the sac, and by this means the trouble may sometimes be cured at one sitting. Electrolysis[1] is often very useful in these cases, as is also syringing the passages with a solution of boracic acid. In most cases, however, the canaliculus has ultimately to be slit up. The obstruction may be due to an enlarged caruncle, which should then be cut off with a pair of scissors.

Fig. 71. Wire Gauge

Fig. 72.—Small Lachrymal Probes

The operation of slitting up the lower canaliculus.—The instruments required are a probe-pointed knife (Weber's) (fig. 73), small fixation forceps and scissors. The operation may be done without an anæsthetic, but cocaine is generally used by injections through the punctum. The patient is either sitting up in a chair or lying down, and the operator, standing behind him, draws the lower lid downwards and outwards with a finger, so as to expose the punctum. If the punctum be

[1] *Brit. Med. Journ.* 1887, ii. p. 1371.

very small, it must first be dilated by small probes or a wire gauge until the probe point of the knife can be introduced. The canaliculus knife is passed vertically into the punctum, and the handle being turned and lowered, the knife is passed horizontally, with its cutting edge upwards, along the canaliculus until its point is felt to touch the mucous membrane lining the inner wall of the lachrymal sac. The knife is then raised forwards and upwards, and its handle describes an arc of 90° when it becomes parallel with the nose; by this means the canaliculus is laid open as far as its entrance into the lachrymal sac. Any blood being sponged away, the mucous membrane at the inner and posterior border of the conjunctival incision is seized with a pair of forceps, and a small piece of it cut off so as to prevent the wound healing too soon. The upper canaliculus is not so often operated on, though it is more easily divided.

Fig. 73.—Canaliculus Knife

Inflammation of the lachrymal sac is frequently met with, and is generally the result of catarrhal inflammation of the mucous membrane extending from the nose. It may be chronic or acute and is accompanied by epiphora. In the *chronic* form, the patient rarely complains of anything but watering of the eye and a little thickened discharge from it at times. Fulness is generally to be seen above the internal tarsal ligament, and on pressure over the sac, some viscid fluid, consisting of mucus or muco-pus, can be squeezed out through the puncta. In other cases, a distinct rounded, soft and elastic swelling about the size of a pea, can be seen in the region of the

lachrymal sac. This swelling, which is the distended sac, is known as a *mucocele*, and its contents can by pressure be evacuated through the puncta, though it soon fills again. As a rule, the contents of the sac after a time become purulent by the introduction of micro-organisms, and a lachrymal abscess results. It may be caused by a catarrhal swelling of the mucous membrane of the nasal duct, preventing the discharge of tears, or by a stricture of the nasal duct.

The *treatment* may consist in dilating the canaliculus by probes, slitting up the canaliculus, syringing the sac and duct with antiseptic lotions, or, if a stricture of the sac be present, dilating it by probes or introducing a style.

Acute inflammation of the lachrymal sac (acute dacryocystitis) is the form which gives rise to lachrymal abscess. In almost all cases there has been some previous trouble of the lachrymal passages accompanied by epiphora. Suddenly the region of the sac becomes painful, exceedingly tender to touch, swollen, and the skin over it shining red, and œdematous; this redness and swelling spread to the lids, cheek, and side of the nose; the caruncle and conjunctiva are generally congested. The swelling over the sac, which is somewhat pear-shaped with the stalk end at the inner canthus, increases in size, stretching the skin over it, which as a rule bursts and discharges pus. The wound tends to become fistulous, and the edges of it to ulcerate, and in such cases the fistula may remain for some weeks or months, but eventually tends to heal up. The abscess recurs if the cause be not properly treated.

Chronic inflammation of the lachrymal sac generally precedes the acute form, and the exciting cause is entrance of micro-organisms into the lachrymal sac.

The disease may be mistaken for erysipelas, but the onset of the latter is always accompanied by severe consti-

tutional symptoms, such as vomiting, rigor, headache, and high temperature 104° to 105°, and its rash has a raised and well-defined spreading margin.

Treatment.—Locally, hot fomentations of boracic acid or boro-glyceride; as soon as pus is known to be present, a vertical incision through the skin should be made into the sac. Occasionally the abscess may be evacuated by slitting up a canaliculus. After the sinus has healed, and the surrounding inflammation subsided, probes should be passed, or the canaliculus slit up, in order to treat the stricture or other cause of the abscess. The general treatment at first should be by a brisk purge.

Probes of different sizes and kinds are used for passing down the nasal duct. The bulbous probes (fig. 74) are a very convenient form, but should not be grooved as they are then difficult to keep clean. They are numbered from 1 to 8, but it is rarely advisable or necessary to use a larger size than No. 4.

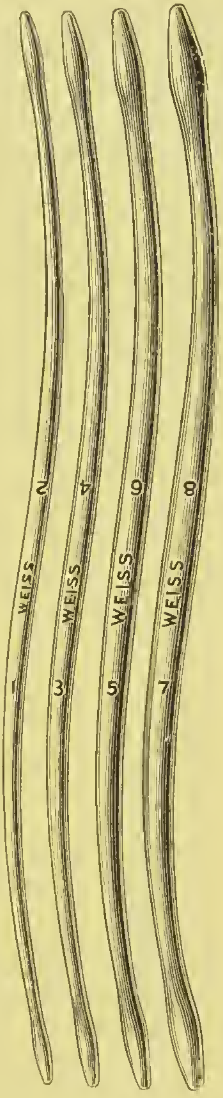


FIG. 74.—BULBOUS POINTED PROBES

To pass a probe down the nasal duct.—The operation is a painful one, and cocaine should be always used, by injection along the canaliculus. The operator, standing behind the patient, should hold the probe between his finger and

thumb, and introduce it into the punctum. The lower lid being pulled downwards and outwards, the handle of the probe should be depressed, and its end passed along the canaliculus till the point is felt to touch the mucous membrane of the inner surface of the lachrymal sac. The end being kept in contact with the inner wall of the sac, the probe is raised till it becomes parallel to the nose, when its end should be over the entrance to the nasal duct. With gentle force the probe should be pressed downwards and slightly backwards and outwards, when it should glide easily into the nasal duct. As a rule, the simple passage of a probe should not be attended by hæmorrhage. The duct may be dilated either gradually, a larger probe being passed at each sitting, or rapidly by passing probes of increasing sizes at one operation.

Obstruction of the nasal duct may occur anywhere in its course, but usually at the upper part. The symptoms are very variable, and comprise epiphora and usually an external swelling (mucocele or lachrymal abscess) over the lachrymal sac. The puncta and canaliculi may be normal, and the position of the stricture is diagnosed by passing a probe.

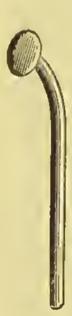


Fig. 75.—Lachrymal Style

The duct may be obstructed by changes in its mucous membrane owing to the spread of catarrhal inflammation from the nose, or, more rarely, from the conjunctiva; by periosteal changes in syphilitic or strumous subjects; by pressure from tumours; or by injury to the nasal bones.

The treatment consists of dilatation by means of probes, with or without previous division of the canaliculus. In obstinate cases a style (fig. 75) may be inserted in the duct and left there for a week or longer. Syringing the duct with boracic acid and electrolysis are useful in some cases. In very obstinate cases, after the

canaliculus has been slit up, a small stout knife may be passed down the duct through the stricture, which is then divided, and large probes passed down a few days afterwards.

Occasionally a *fistula* forms which is very difficult to heal, and the best treatment is to use the actual or galvano-cautery to its edges and to the walls of the sinus, or in some cases to pare the edges and bring them together. After such operations the canaliculi and nasal duct must be kept patent by probing or by a style.

Obliteration of the lachrymal sac is occasionally called for as a last resource in cases of fistula accompanying disease of the bone and constant discharge. This is effected by laying the sac freely open and applying the actual cautery or caustics to the wall of the sac, or by dissecting it out.

CHAPTER XIX

DISEASES OF THE EYELIDS

Anatomy and physiology.—The eyelids are developed from two folds of skin, which have become modified for the protection of the eyeball, and contain muscular fibres for their movement, plates of fibrous tissue (tarsi) for the maintenance of their shape, and numerous glands. The lids are elliptical in form and joined together at their outer and inner margins (*canthi*, κανθός, corner of eye); their free edges form the boundaries of the palpebral fissure, and by their apposition convert the conjunctiva into a closed sac.

The margins of each lid are bevelled and bounded in front by a rounded anterior lip, from which the lashes spring, and behind by an angular posterior lip, near which are the openings of the Meibomian glands. The area between these two lips is known as the inter-marginal space.

The external surface of the lid is composed of skin which, except for its delicate texture, is the same as that of any other part of the body.

The subcutaneous tissue, very loosely attached to the skin, contains the follicles and sebaceous glands of the fine hairs seen on the exterior of the lid, and is peculiar from having no fat in its meshes. Beneath this is the orbicularis palpebrarum, a plane of striped muscular fibre arranged concentrically around the palpebral fissure. It forms a sphincter attached at the inner side by the internal

tarsal ligament to the superior maxilla, and at the outer side by the weaker external tarsal ligament to the malar bone. Beneath the muscle is a layer of connective tissue containing the follicles of the lashes and the modified sweat glands of Moll.

The *tarsi*, generally known as the tarsal cartilages, consist of firm connective tissue, and to the one in the upper lid is attached the levator palpebræ muscle. Imbedded in the ocular surface of the tarsi are the Meibomian glands, resembling in structure sebaceous glands, and closely adherent to the ocular surface of the tarsi is the palpebral conjunctiva.

The *orbicularis* muscle is supplied by the seventh nerve, and its action is to close the lids ; when it is paralysed the eye remains permanently open (lagophthalmos) and there is no power to close the lid.

The *levator palpebræ* is supplied by the third nerve, and its function is to raise the tarsal cartilage, and with it the upper lid ; paralysis of the muscle is followed by inability to raise the lid (ptosis). Its action is closely associated with the superior rectus, and when the eye is raised the lid follows it.

The *muscle of Müller* is composed of unstriped muscular fibre and supplied by the sympathetic ; it opens the lids slightly, as is seen in the dilatation of the palpebral aperture produced by cocaine, and when it is paralysed the lids are partially closed.

The lids are opened by the levator palpebræ raising the upper lid, aided by the contraction of the muscle of Müller.

The lids are closed by the contraction of the orbicularis palpebrarum and the relaxation of the levator palpebræ. The closure of the lids may occur voluntarily, but as a rule it is reflex, the afferent impulse being from the sensory branches of the fifth about the face and eye, or from light exciting the retina.

The use of the lids is to lubricate the eye by the secretion of the palpebral conjunctiva and the Meibomian glands, and to protect it from injury and undue exposure.

The involuntary lid-wink, which takes place about twice a minute, helps to direct the tears to the puncta and canaliculi, to clear mucus from the surface of the cornea, and to keep off foreign bodies; it is reflex from the fifth nerve supplying the cornea and conjunctiva, and becomes a rhythmical automatic act.

CONGENITAL AFFECTIONS.—**Ptosis** is described at p. 293.

Coloboma is present occasionally as an irregular triangular cleft with the base at the ciliary margin, and may occur in the middle or at the inner third of either lid. Other congenital anomalies, as hare-lip, cleft-palate, are often associated with this condition.

Epicanthus, generally bilateral, is a fold of skin extending from the root of the nose over the internal canthus, the outer edge being concentric and free, and the upper and lower portion being lost in the skin of the lids. In a slight degree, it is often seen in young children with a flattened bridge of the nose, and usually disappears or becomes much better when the bridge is developed. In some cases, which are rare, it is a serious deformity, and must be operated on by dissecting up an elliptical piece from the root of the nose and stitching it together, leaving a median scar.

INFLAMMATORY AFFECTIONS OF THE LIDS.—**Ciliary blepharitis** (tinea tarsi) is the most common inflammatory condition of the lids; cases vary greatly in severity, but may be divided into two classes, squamous and ulcerative.

The *squamous* variety is the more frequently met with, and affects all ages and ranks of life. It is characterised by branny scales at the bases of the lashes,

and as a rule by a reddened appearance of the margins of the lids. In adults, it is often present at the canthi, especially the external, and is then termed *angular* blepharitis.

The *ulcerative* form occurs chiefly in children, and the border of the lid is covered with yellowish crusts, matting together the eyelashes. On washing away these crusts, small ulcers and pustules are seen about the hair follicles, and these readily bleed. The lashes tend to come away with the crusts and are broken and stunted.

In old and neglected cases the border of the lid presents a red, glazed appearance, like raw beef; the edges are rounded off with a few scattered lashes or none at all. This condition is known as *lippitudo.*

Ciliary blepharitis is a very chronic disease, and is frequently accompanied by conjunctivitis. It may give rise to scarring of the lid border, with eversion of the puncta and epiphora, and, in severe cases, to misplacement of the lashes, and even ectropion or entropion.

Causation.—It is most often found associated with refraction errors, especially hypermetropia and hypermetropic astigmatism, in lachrymal troubles, and in chronic conjunctivitis. Children living under bad hygienic and dietetic conditions are liable to this disease, which affects those of tubercular diathesis, and is also a sequela of the exanthemata, particularly measles. It is met with amongst persons working in an irritating atmosphere and in those exposed to dust and wind, is prevalent at certain seasons of the year, and is very apt to recur.

It must not be diagnosed from the mere presence of dried secretion about the lashes until conjunctival and lachrymal affections have been eliminated. A history of its chronic nature greatly helps the diagnosis.

The *prognosis* in cases associated with refraction error is good if proper glasses are worn, but in most other cases it is very difficult to effect a complete cure.

Treatment.—In the *squamous* variety the scales must be washed off with an alkaline lotion, as bicarbonate of soda (F. 27) or borax (F. 25), every morning and evening with a cotton-wool sponge. Afterwards, vaseline or zinc ointment should be applied by the finger along the conjunctival edge of the lower lid, so as to prevent the lids sticking together during sleep. The refraction must always be tested.

In the *ulcerative* form, after the crusts have been gently washed off with the alkaline lotion, the ulcers should be painted with yellow oxide of mercury ointment (F. 40) or nitrate of silver solution (F. 35). In acute cases all the lashes may be removed by forceps and the raw surface painted with nitrate of silver. In the very chronic form, with eversion of the puncta and marked epiphora, the canaliculus should be slit up.

A stye (hordeolum; *hordeum*, barley) is a limited acute inflammation of the connective tissue and sebaceous glands about the follicle of an eyelash, and, like a boil, generally ends in suppuration. It is marked by severe throbbing pain and commences as a red swelling at the lid margin, accompanied as a rule by œdema of the lid and chemosis of the conjunctiva. When suppuration occurs there is a yellow raised area at the most prominent part of the swelling. A stye situated near the inner canthus is apt to involve the punctum and set up lachrymal trouble. Styes may appear singly or in crops.

Causation.—They occur at any age in people who are out of health, and are common in young adults, in whom they are frequently associated with acne spots, constipation, and refraction errors, as hypermetropia.

Treatment.—In the earliest stages painting with silver nitrate or rubbing with mercurial ointment may check the development. Hot fomentations or compresses of boracic acid should be used, and the pus may be evacuated by pulling out an eyelash or incising the

swelling. The general health should be attended to, and sulphide of calcium in half-grain doses has been much recommended; any refraction error must be corrected by glasses.

In **erythema** the lid is slightly swollen, and the colour, which is bright red, disappears on pressure. It is unaccompanied by pain or constitutional disturbance, and may be treated by lead lotion (F. 23).

Erysipelas is occasionally met with, and is accompanied by its usual symptoms of high temperature, shivering, or general constitutional disturbance. The lid feels hot to the touch, is rose-red and shiny in appearance, much swollen, and the skin often raised in vesicular patches. There is inability to open the lid, and the conjunctiva is congested and chemosed. It may end in resolution or in the formation of a blepharal abscess. Among the causes are severe chill, a cut or injury to the lid, or the presence of pus in the immediate neighbourhood. The treatment is best commenced by a brisk purge followed by quinine; the lid should be fomented with hot boracic acid lotion.

Acute blepharitis (*βλέφαρον*, eyelid), or general inflammation of the lid, is characterised by great swelling and redness, mapping out the whole area of the lids. It generally tends to get well, but sometimes ends in suppuration.

Blepharal abscess.—Abscess of the lid is accompanied by severe pain, and great hardness of the palpebral tissues; on suppuration occurring, the whole lid becomes a fluctuating swelling, which unless opened tends to slough.

The causes are injuries, erysipelas, the exanthemata as measles, and purulent ophthalmia.

The treatment is by hot fomentations, and the evacuation of the pus, if formed.

Œdema of the lid may be of idiopathic origin, but is generally only a symptom of disease in some other structure. It is found in cases of conjunctivitis, lachrymal

abscess, stye, inflammatory affections of the orbit as cellulitis, periostitis and abscess, and occasionally in orbital tumours. A common cause is a bite of small insects, and it is also a symptom of nephritis. It should be treated by a pressure bandage or by evaporating lotions.

For **inflammations** of the conjunctival surface of the lids, as granular lids, &c., the reader is referred to Chapter IV.

TUMOURS OF THE LIDS. **Infective inflammatory tumours.**—*Syphilis* is met with as a primary sore (chancre) on the skin or conjunctival surface of the lid, and is always accompanied by enlargement of the preauricular (parotid) or angular lymphatic glands. In the tertiary stage it is found as gummata and ulcers. *Tubercle*, *lupus*, and *vaccinia* are occasionally seen.

Innocent new growths.—*Meibomian cyst* (chalazion, *χάλαζα*, hail) is a chronic overgrowth in connection with a Meibomian gland. It occurs as a small painless swelling adherent to the tarsus, the skin of the lid being as a rule freely movable over it, and the size varying from that of a pea to a hazel nut.

The overlying skin is generally natural in appearance, but may be a little congested; on the conjunctival surface there is a dusky or bluish spot, due to thinning from pressure of the tumour. If perforation has taken place, there will be a viscid discharge, or a button of granulation tissue sprouting from the cavity of the tumour. These cysts may occur singly, but usually more than one is found, and in some cases there is a succession of them for some years. They increase in size very slowly and without pain, and may disappear spontaneously, or their contents undergo degeneration or suppuration.

Pathology.—Chalazion originates from the irritation due to accumulation of the contents of the gland acini, and when fully developed its structure somewhat resembles granulation tissue. From the breaking down of the

central parts, the growth becomes cystic and filled with soft gelatinous substance, and unless the tumour has lasted a long time no definite capsule is found.

Diagnosis.—A stye sometimes resembles a chalazion, but the acuteness of onset and great pain in the former, and the position and adherence of the latter to the tarsal cartilage, are the distinguishing points.

The *treatment* is to let out the contents freely, making sure that none are left; otherwise the tumour is very liable to recur. This should be done by everting the lid, and with a small knife making a horizontal or crucial incision through the palpebral conjunctiva at the point of discolouration. The contents should be removed by a small spoon (fig. 76) or squeezed out. After the operation, the cavity of the cyst will fill with blood, and the swelling will not disappear for a fortnight or more. If the cyst be very large it may be dissected out from the skin surface of the lid.

FIG. 76.—MEIBOMIAN SPOON.

Small concretions in the glands are found very frequently, in gouty persons, on the palpebral conjunctiva, and are cheesy or calcareous in consistency. They produce irritation of the cornea and conjunctiva, and should be picked out with a sharp needle or point of a knife.

Molluscum contagiosum is a small, rounded, yellowish-white tumour occurring on the skin of the lids, and varies in size from a minute spot to that of a pea. There is a depression at the centre of its superior surface, generally dark in colour, which is the orifice of the hair follicle.

Molluscum originates in the sebaceous glands, and the contents are closely packed sebaceous material.

The treatment is to transfix and divide it with a knife, and then squeeze out the contents between the thumb nails.

Milium is a small white elevation about the size of a pin's head, found on the skin surface of the lids, and due to the accumulation of the contents of a sebaceous gland.

Transparent cysts are met with in the margins of the lids, and should be treated by snipping off a piece of the wall with a pair of scissors.

Nævi are found as small red specks or patches, or as large subcutaneous masses. Small ones are best treated with a red-hot needle or ethylate of sodium, and the larger ones by electrolysis.

Papillomata or warts, cutaneous horns, and adenomata also occur along the margin of the lids, and should be removed.

Malignant tumours.—*Epithelioma* and *sarcoma* occasionally occur. *Rodent ulcer* is the most common, and is characterised by the slowness of its growth and by the lymphatic glands not being affected as a rule. The disease is rarely seen under the age of forty, and commences as a pimple or wart, generally about the inner canthus, being covered at first by a scab, which the patient tears off from time to time, leaving an ulcerated surface. The edges of the ulcer are raised, nodular, and very hard, and occasionally the surface may heal up on one side, and increase in growth at the other. In some cases the disease may remain superficial for years, but in others it progresses rapidly, eating away the tissues of the skin, muscles, orbital bones, and even the eyeball itself.

The treatment is to remove the growth and the tissues around it, and it is well afterwards to cauterise the wound. It generally recurs, and should be removed over and over

again, as the removal gives the patient relief, if only for a time.

AFFECTIONS OF THE MUSCLES.—**Ptosis** (*πίπτειν*, to fall), or drooping of the eyelid, is marked by inability to raise the upper lid, and is either congenital or acquired. *Congenital ptosis* is not uncommon, and the subjects of it have a characteristic way of carrying the head thrown back, with the eyebrows much elevated from over-action of the occipito-frontalis muscle. In many cases the superior recti are weak, and the backward position of the head is partly to compensate for the impaired upward movement of the eyeball. It varies greatly in degree, and is generally bi-lateral, though one eye only may be affected. The *causation* is defect of the levator palpebræ muscle, and this is often hereditary.

Acquired ptosis results from injury or disease. Traumatic cases follow blows on the eye, and are often associated with mydriasis. The other causes are paralysis of the third, or sympathetic, nerves, the result of syphilis, rheumatism, or cold; spasm of the orbicularis muscle; superabundance of loose skin. Partial ptosis exists in cases of old granular conjunctivitis from thickening of the lids.

Treatment.—In paralytic cases constitutional treatment is the most important, and this may be combined with electrical stimulation and massage.

Surgical treatment.—It must always be borne in mind when treating these cases that too much skin must not be taken away, as the eye would thereby be left uncovered, and the patient in a worse state than before. The operations are numerous, and are chiefly directed to produce shortening of the lid by removal of the skin, or to procure union between the occipito-frontalis muscle and the tarsus.

Removal of a piece of skin [1] is best performed by pinch-

[1] Von Graefe, *Archiv f. Ophth.* ix. 2, 57.

ing up a portion of it with a pair of blepharal forceps (fig. 77) parallel to the lid border, and removing it with scissors. The connective tissue and orbicularis muscle corresponding with the incision may then be dissected and removed, and the edges of the wound brought together by sutures.

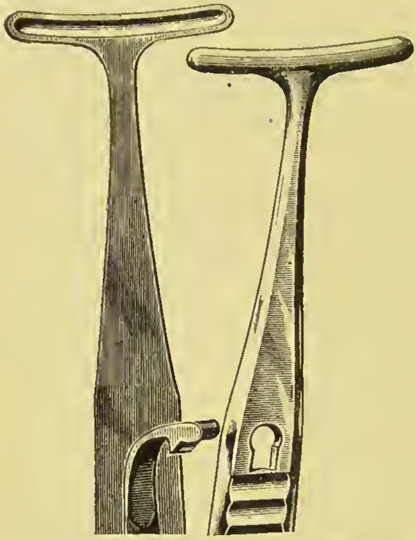


Fig. 77.—Blepharal Forceps

Operations for increasing the action of the occipito-frontalis muscle on the upper lid range from subcutaneous sutures of silk or wire, passed from the tarsal border to above the eyebrow, to more complicated methods, such as fastening a flap of skin dissected from the lid to the forehead (Panas), or advancement of the tendon of the levator palpebræ (Eversbusch).

The operation I generally perform, and which has given me very good results, is a subcutaneous separation of the skin of the lid from the orbicularis muscle. The lid being held by a pair of entropion forceps (fig. 80) or stretched over a horn spatula, a Graefe's knife with its edge upwards is introduced through the skin at the outer side, as in fig. 78. The knife is passed beneath the skin till its point reaches the inner side of the lid, and is carefully swept subcutaneously round the lid above, freeing the skin from the orbicularis muscle. It may then be made to free the skin below as far as the margin of the lid. A silk suture is threaded with a needle at either end. One of the needles is introduced at the junction of the outer third with the inner two-thirds of the lid, about 2 mm. from the margin, and is brought

out just above the eyebrow. The other needle is introduced 2 mm. away from the first, and brought out above and parallel with it. Another suture is passed in the same way at the junction of the inner third and outer two-thirds, and brought out above the eyebrow. The sutures are then drawn as tight as necessary, their ends tied over a piece of indiarubber tubing, and left thus for some days.

Blepharospasm, or contraction of the orbicularis muscle, is, as a rule, involuntary. It is most often caused

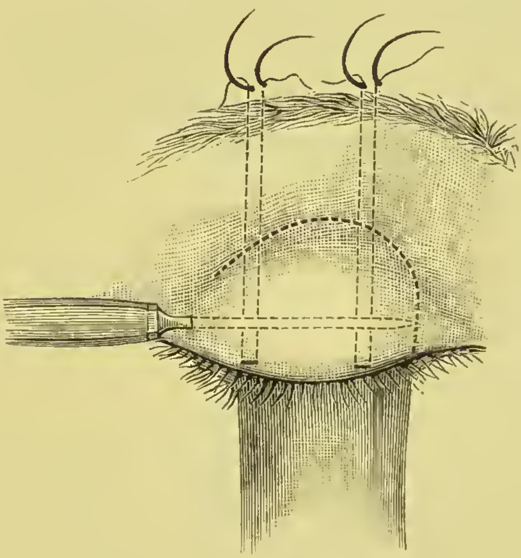


FIG. 78.—PTOSIS OPERATION

by irritation of branches of the ophthalmic division of the fifth nerve in affections of the cornea, conjunctiva or lids, such as foreign bodies, keratitis, corneal ulcers and ingrowing lashes. Less frequently, it may be produced by decayed teeth or affections of the nose, and occasionally it occurs in children, and even in adults, without any apparent cause. If the origin be due to irritation of a nerve, pressure over this nerve will as a rule elicit pain, and thus confirm the diagnosis.

If the result of corneal ulcer or other ocular affection this must be treated, and the spasm generally passes away, but may last for some time after the exciting cause is cured.

If no ocular affection or other source of irritation can be found, the spasm may be relieved by local applications of cocaine, hypodermic injections of morphia, or as a last resource, a general anæsthetic as chloroform.

Nerve-stretching, or even section of branches of the fifth nerve, are occasionally followed by good results.

Slight rhythmical involuntary contractions of portions of the orbicularis are often complained of by patients who are out of health, especially if suffering from digestion troubles or from an error of refraction, usually hypermetropia. The peculiar wriggling and jerking sensation is commonly known as 'live blood,' and must be treated by tonics and massage of the lid.

Children are often affected with a great increase in the number and degree of the involuntary lid winks (habit spasm). This is associated with errors of refraction, general health, and conjunctival irritation, and disappears on removing the cause.

A more chronic form is met with, generally in adults, affecting only one eye, and consists of a succession of choreic movements in the orbicularis palpebrarum, and often of the other muscles of the same side of the face. The attack commences as a mere lid twitch, which gradually becomes more severe, till the eye may be closed for some seconds. Errors of refraction or conjunctival troubles may be the first cause, and the attacks are increased by excitement. This condition is very intractable to treatment.

Lagophthalmos (λαγώς, hare), or inability to close the lids, generally results from paralysis of the orbicularis muscle following lesion of the seventh nerve, but may be produced mechanically by exophthalmos.

In these cases the danger to the eye is from the ex-

posure of the cornea to the air and to foreign bodies, arising from the non-closure of the lids and the absence of the involuntary lid wink. In paralytic cases, the treatment is constitutional, with galvanism and massage locally. In the non-paralytic cases, the cornea must be protected by bandaging or strapping the upper lid over the eye, and in extreme cases the operation of tarsoraphy is indicated.

The operation of *tarsoraphy*, or artificial union of the edges of the lids, is done in order to protect the cornea in cases of severe exophthalmos as in Grave's disease, ectropion, lagophthalmos, and in paralysis of the fifth nerve. It is generally performed at the external canthus, but sometimes at the middle or along the whole margin of the lid. The operation is done by paring with a small scalpel the intermarginal space of each lid, and then uniting the raw surfaces by sutures. In some cases the roots of the lashes may be included in the portion removed from the lids.

Trichiasis (*θρίξ*, hair) is the condition in which the eyelashes tend to turn inwards towards the eyeball, instead of taking their normal outward sweep. As a rule, only a few lashes are displaced, but sometimes a group or even the whole row may turn inwards, and in such cases entropion is present. *Distichiasis* (δίς, double ; στοῖχος, row) is the term applied to the presence of two rows of lashes in the lid, the outer growing forwards, and the inner or posterior turning backwards ; it may arise from inflammatory changes in the lid, or occasionally exists as a congenital defect. The most frequent *cause* is lid trouble from scarring of the palpebral conjunctiva, the effect of granular conjunctivitis, or its too vigorous treatment by caustics. It may also result from blepharitis and burns or operations on the lid.

Treatment.—When only a few lashes are misplaced they may be removed (*epilation of the lashes*) by cilium

forceps (fig. 79), and it is important that the lashes should be seized near their bases and drawn straight out, or they will easily break off. The ciliary border must be carefully examined for the faulty lashes, as they are often very small and down-like, and a good plan is to use the objective lens as a magnifying glass. The drawback to epilation is that the lashes grow again in a few weeks, and therefore necessitate frequent removal.

Fig. 79.—Cilium Forceps

A very effectual method is by *electrolysis*, after which the lashes do not, as a rule, grow again. The mode of procedure is to attach a fine needle to the negative pole of a battery of four or five cells, and to place the positive pole on the temple of the same side. On now closing the circuit by applying the needle to the hair follicle, a few bubbles are seen round the needle; the lash is easily removed by forceps, and its follicle is destroyed by the alkali produced.

The operation is a painful one, and cocaine should be previously injected along the ciliary border of the lid.

A method to correct the faulty direction without loss of the lashes is by passing the two ends of a piece of horsehair or fine silk through the eye of a small curved needle, thus making a loop. The needle is then passed through the lid margin close to the base of the ill-directed lash, and its point brought out above at the spot where it is desired the lash should grow. The loop is placed carefully round the base of the lash, and on pulling the silk through, the lash will follow and gain its new position.

In some cases the lashes may be excised by making incisions with a small scalpel in the intermarginal space on either side of the faulty lashes, and dissecting out a flap containing them. Any hair-bulbs left are seen as small black points in the wound, and must be pulled out with forceps. The edges of the wound should then be stitched together.

Other operations are described under 'Entropion.'

Entropion (*ἐν*, in ; *τρέπειν*, to turn), or inversion of the eyelid, may affect either the upper or lower lid or both simultaneously, and may be complete, involving the whole length of the lid, or partial. In complete entropion the edges present a rounded appearance from the rolling in of the lid and from the change in the normal direction of the lashes ; trichiasis is always present.

Entropion generally sets up much irritation of the eye, and is marked by lachrymation, photophobia and blepharospasm. When the condition has existed some time, it is complicated by superficial keratitis, and in a later stage by pannus.

The *causes* are *cicatricial*, from contractions of the conjunctival surface of the lid following granular, purulent and membranous conjunctivitis, the abuse of caustics applied to the conjunctival surface of the lid, essential shrinking of the conjunctiva, and pemphigus ; and *muscular* (spasmodic), from spasm of the orbicularis. This latter class is often seen in old people, and is due to the action of the orbicularis muscle on the lax and atrophied lids. It is frequently met with after operations, as cataract, in which the eye has been bandaged for some time.

It also occurs from want of support after excision of the eyeball or in cases of atrophied globe.

Treatment.—In *spasmodic* cases in old people, the patient should be instructed to pull down the lower lid with his finger for some minutes at a time, or collodion may be painted on the skin below the lid. Another method

is to cut a piece of adhesive plaster, about 2 inches long, with its upper part curved to correspond to the shape and length of the lid. The plaster is applied to the skin just below the lid margin. An eversion of the ciliary border is obtained by pulling the unattached end of the plaster directly downwards, and fixing it on the skin of the cheek as low down as possible. By this means, slight ectropion is maintained, and the plaster may be left on for some days. If these means fail, a horizontal fold of skin may be pinched up close to the margin of the lid, and silk sutures passed through it from above downwards, which are then tied over a roll of plaster or rubber tubing, and may be left in for a week or more.

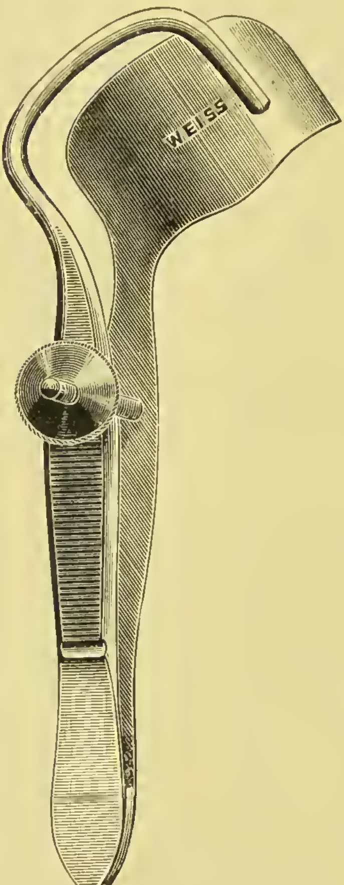


Fig. 80.—Entropion Forceps

Canthoplasty is sometimes useful in these cases, and excision of a horizontal elliptical piece of skin below the lid often gives good result.

In *cicatricial* cases, chiefly affecting the upper lid, numerous operations have been devised, and are best executed by fixing the lid first with a pair of entropion forceps (fig. 80) so as to render the operation bloodless. The tarsal plate may be cut through with a small scalpel, by a horizontal incision through the palpebral conjunctiva about 4 mm. away from the ciliary margin (Burow). In some cases, a piece of the tarsal plate may be excised, and if

the result is not satisfactory, the operation may be combined with removal of a fold of skin from the external surface of the lid.

A very good method in extreme cases is to make a horizontal incision, the length of the lid close to the intermarginal space, and to fill up the gap thus formed by sewing in a piece of mucous membrane, removed from the mouth or cheek (Van Millingen).

Transplantation of the lashes may be performed by making a horizontal incision down to the roots of the cilia in the intermarginal space corresponding to the lashes to be removed. A second and parallel incision is then made through the skin close to the cilia, and the bridge of skin bearing the cilia is dissected up. A third incision, parallel to the other two, is made about 3 mm. above the second, and the skin between the second and third incisions dissected from the subcutaneous tissue. The first bridge containing the cilia is then passed beneath the second bridge, and its upper border is sutured to the skin above; the lower border of the second bridge is then sutured to the palpebral conjunctiva, and the adjacent borders of the bridges are then sutured together. By this means a flap of skin takes the original position of the lashes, and the only objection to this operation is that sometimes the scanty hairs on the skin flap tend to grow and irritate the eye. This is a modification of Spencer Watson's operation, in which a flap containing the lashes with its base near the inner or outer canthi is interchanged with a skin flap from the lid.

Ectropion (ἐκ, out; τρέπειν, to turn), or eversion of the eyelid, is the condition when the lid is more or less turned away from the eyeball, exposing the palpebral conjunctiva; it varies greatly in degree, from a simple falling away of the lid to a complete eversion and exposure of its mucous surface.

The chief symptom, *epiphora*, is most marked when

the lower lid is affected, and is due to the punctum being no longer approximated to the eyeball. From the tears flowing over, excoriation and inflammation of the lid is usually produced, and chronic conjunctivitis set up. Owing to exposure of the eyeball to the atmosphere and dust, keratitis and corneal ulcers may ensue, and even perforation and loss of the eye.

In slight cases, the eye may be little affected, owing to the protection afforded to the cornea by the upper lid. In severe cases, the reddened and fleshy look of the exposed conjunctiva produces a great deformity.

Causation.—Ectropion of the lower lid is often found in elderly people, from atrophy and want of tone of the tissues. It is met with in paralysis of the orbicularis palpebrarum; in chronic conjunctivitis from thickening of the mucous membrane; and in blepharitis of long standing. It may be caused by cicatrices of the lids or surrounding tissues from burns, wounds and ulcers. A severe form is met with in strumous children after caries of the orbit. In children, the lids may be everted from spasm of the orbicularis. It may be occasioned by great swelling and chemosis of the conjunctiva, as in purulent and granular conjunctivitis, and also by the protrusion of the eyeball in exophthalmos.

Treatment.—In slight cases, especially in the senile form, the lower lid may be gently massaged and astringent lotions and ointments, as sulphate of zinc, applied to the conjunctival surface. If the punctum is much displaced, the canaliculus should be slit up. When great hypertrophy of the conjunctiva of the lower lid exists, much good may result from cauterisation by a pencil of nitrate of silver along the whole length of the palpebral conjunctiva. Failing this, the mucous surface of the lid may be scarified, or a long oval-shaped piece of the conjunctiva may be removed with scissors, and the edges of the wound brought together with fine sutures.

The eversion of the lower lid may be successfully overcome by means of sutures (Snellen, Argyll Robertson). There are several ways of passing them, but the following is probably the best. A fine waxed silk suture is threaded with two medium-sized half-curved needles, one of which is entered at the most prominent part of the conjunctival surface of the lower lid about the junction of the middle and inner thirds, and passed through its substance as far as the subcutaneous layer; it is then directed downwards in this layer to the lower margin of the orbit, where it is brought out through the skin with the suture. The second needle with the other end of the suture is entered in the fornix of the conjunctiva, in a line directly below the entry of the first needle, and is brought out on the cheek about 2 mm. below the exit of the first needle. Another suture is passed in a similar manner at the junction of the outer and middle thirds of the lid, and, if necessary, a third suture between the other two. The sutures are now pulled tightly till a considerable amount of entropion is produced, and a small roll of plaster is laid on the cheek between the two ends of each suture, which are then tied over it. The threads may be tightened from day to day, and removed about the end of a week, or earlier if much irritation is caused.

Wharton Jones' method is known as the V-Y operation. A V-shaped incision is made through the skin and subcutaneous tissue immediately below the lower lid; the flap thus mapped out is freed from the surrounding tissues, and the lower edges of the wound brought together with silk sutures, thus pushing the V-flap upwards, the resulting scar being in the shape of the letter Y.

Cicatricial ectropion, where the lid is dragged down from scars in its neighbourhood, is exceedingly difficult to treat. Some relief may be obtained, when the cicatrix is adherent to the subjacent bone, by separating the adhesions with a small scalpel passed subcutaneously

between the skin and periosteum, and then sliding the skin upwards and keeping it in the new position by strapping.

Canthoplasty is the operation for enlarging the palpebral aperture, and is performed by cutting through the entire thickness of the tissues at the external canthus with a strong pair of blunt scissors. The conjunctiva may then be stitched to the edges of the wound by sutures if a permanent enlargement is needed.

Blepharoplasty.—In cases of partial or complete destruction of the eyelid by burns or ulceration, the loss of substance may be repaired, after all signs of active inflammation have ceased, by small skin grafts or by transplantation of a large piece of skin. This latter method is done by dissecting up a flap of skin from the neighbouring parts (for the upper lid from the temporal region, and for the lower, from the cheek or side of nose) in such a way that the flap, when fixed in its new position, is still connected with the skin by a pedicle containing blood-vessels. It is important, to ensure success, that the piece of skin transplanted should be larger than is apparently wanted, that all bleeding should be stopped before the flap is sutured in its place, and that the flap should be kept warm by hot sponges during the operation.

Phtheiriasis (φθείρ, a louse).—The pediculus pubis is occasionally found clinging to the eyelashes, and owing to the irritation set up by it and the presence of its eggs (nits), which look like fine brown powder, the case may be mistaken for ciliary blepharitis, but can be at once diagnosed by the aid of a magnifying glass. The parasites and their eggs should be removed with forceps, and the lashes washed twice a day with a solution of perchloride of mercury, or smeared with a mercurial ointment.

Xanthelasma (ξανθός, yellow; ἔλασμα, plate) is seen on the skin surface of the lids, generally about the inner

canthus, as slightly raised soft yellowish masses which produce no irritation. It occurs in elderly people, especially females of a bilious temperament, and is very rare. The patches may be excised provided no alteration of the position of the lid is likely to be produced by the operation.

Symblepharon (*σύν*, together; *βλέφαρον*, eyelid), is the adhesion of the conjunctival surface of the lid to the ocular conjunctiva or to the cornea, and most frequently occurs in connection with the lower lid. The extent of union varies from bands or cords to complete and intimate adhesion; in the latter case, the movements of the eyeball are restricted, and vision may be much impaired. It is generally unsightly, and the surface often fleshy looking and thick. This condition may be caused by burns with quicklime and acids, and is also a sequel of membranous conjunctivitis, trachoma and pemphigus; it must be distinguished from essential shrinking of the conjunctiva.

The *treatment* consists in dissecting up the lid from its attachment, and filling up the area so exposed by flaps made from the conjunctiva in the neighbourhood, or by grafting pieces of mucous membrane taken from the patient's mouth.

In cases where the adhesions are limited and cord-like, a ligature may be tightly tied round them and allowed to ulcerate through, the ends being removed afterwards by scissors. In all cases, oil should be dropped two or three times a day into the conjunctival sac to hinder reunion.

Anchyloblepharon (*ἀγκύλος*, crooked), or adhesion of the upper to the lower lid, is usually produced by burns or ulceration of their margins, and is rare except at the canthi. The adhesion should be divided by a scalpel, the skin and conjunctiva stitched together, and a probe afterwards passed every day to prevent reunion.

Blepharophimosis (*φίμωσις*, contraction), or narrowing of the lid fissure, may result from granular con-

junctivitis, and is mostly found at the external canthus. It may be relieved by canthoplasty.

Injuries of the eyelids.—*Black eye*, or ecchymosis of the lid, is due to extravasation of blood in its tissues, and is at first bluish-black, changing to greenish-yellow and gradually disappearing. It may last a week or more before complete absorption takes place. It is generally produced by a blow on the eye, but may follow straining in paroxysms of whooping cough, operations as excision or strabismus, and fracture of the skull. It should be treated by cold applications such as lead lotion.

Surgical emphysema is the condition produced by the presence of air, and often blood, beneath the skin of the lid. It is accompanied by considerable swelling of the lids, which pit on pressure and produce a sensation of crackling to the finger. It is usually traumatic, following a blow on the nose, but may result from severe attacks of sneezing or coughing; and is due to rupture of the mucous membrane separating the lids from an air cavity, by which means air finds its way into the cellular tissue of the lids. When recent, it can be best treated by a pressure bandage, and by warning the patient to avoid making any violent respiratory act. It disappears spontaneously.

Incised and lacerated wounds of the lids should be carefully cleansed and their edges accurately brought together by stitches, when they heal quickly.

Burns are caused by hot water, caustics, acids, or by gunpowder, and are only dangerous when the cornea and conjunctiva are involved. They should be treated as burns in any other part, mainly by oily applications.

CHAPTER XX

DISEASES OF THE ORBIT

Anatomy.—The bony orbit is in shape a quadrilateral pyramid, the apex of which is situated behind at the optic foramen and sphenoidal fissure, and the base, forming the anterior aperture of the orbit, is bounded by the free margins of the four bony walls. The superior wall or roof of the orbit has in front a thickened overhanging margin, the supra-orbital ridge; and at the junction of the middle and inner thirds is the notch for the supra-orbital nerve and artery. The roof is thin in its central part, where it may be easily fractured by direct violence; it separates the orbit from the anterior fossa of the skull, and at its outer part there is a depression for the lachrymal gland.

The outer wall separating the orbit from the temporal fossa is divided from the floor by the spheno-maxillary fissure transmitting the superior maxillary nerve and branches.

The floor, or inferior wall, separates the orbit from the antrum of Highmore, and on it is situated the groove, which transmits the infra-orbital nerve and vessels, ending in the infra-orbital foramen. A line joining the supra-orbital notch with the infra-orbital foramen passes between the two upper bicuspid teeth.

The inner wall is the thinnest, and divides the orbit from the nasal cavity, ethmoidal cells and the frontal sinus; it is perforated by the anterior and posterior

ethmoidal foramina. Near its junction with the supra-orbital ridge is the depression for the pulley of the superior oblique, and anteriorly below is the nasal duct leading into the inferior meatus of the nose.

At the apex is found the optic foramen transmitting the optic nerve and ophthalmic artery, and on the outer side and below this is the sphenoidal fissure, transmitting the third, fourth, ophthalmic division of the fifth, and sixth nerves, and the ophthalmic vein opening into the cavernous sinus.

The orbital periosteum is a thick layer lining the bony surfaces of the orbit, continuous behind with the dural sheath of the optic nerve and in front with the periosteum of the bones of the face.

The bony orbit contains the eyeball and the optic nerve, surrounded by the two oblique muscles and the muscular cone of the four recti, joined together by the capsule of Tenon. The other structures are the lachrymal gland with its ducts, the levator palpebræ, the unstriped muscle of Müller, the ophthalmic artery and its branches, the superior and inferior ophthalmic veins, lymphatic vessels, the third, fourth, ophthalmic division of the fifth, sixth nerves and the ciliary ganglion; the orbital fat fills up the spaces between these structures.

The orbits are not quite parallel to one another, but inclined at a small angle so that the axes diverge outwards.

CONGENITAL AFFECTIONS. — *Anophthalmos.*[1]—Complete absence of an eye probably never occurs, but the eye may exist in a rudimentary state as a small button at the back of the orbit, unrecognisable during life. Such cases are associated with small size of the orbit and lids, and also with cysts in these structures, probably formed by degenerative changes in embryonic tissue.

[1] Snell, *Trans. Ophth. Soc.* iv. p. 333; and xiv. p. 190. Lang *Roy. Lond. Ophth. Hosp. Rep.* xii. p. 289.

Microphthalmos, or small eye, is due to arrest of development; the marked diminution of the different measurements is especially well seen in the cornea. It is generally associated with other congenital defects, as cataract or coloboma.

Buphthalmos (megalophthalmos) is described on p. 273.

Exophthalmos (proptosis) is an objective sign and indicates a protrusion of the eyeball, and must be distinguished from an enlargement of the eye itself. It may be unilateral or bilateral, and is present to a greater or less extent in most diseases of the orbit. The displacement of the eye is rarely directly forwards (except in Graves' disease or acute cellulitis of the orbit), being generally in a horizontal or vertical direction, either downwards and inwards, or downwards and outwards. Combined with the displacement, there is marked limitation of the ocular movements in the opposite direction. When the proptosis is unilateral, diplopia is nearly always present, though children seldom complain of it.

In progressive cases, the lids are at first stretched over the protruding eyeball, but as the proptosis increases, the upper lid is no longer able to cover the cornea, and at the same time the lower lid becoming everted, the cornea is exposed and tends to ulcerate. In severe cases, the eyeball may at times dislocate through the lids. Owing to stretching of the optic nerve, papillitis or retro-bulbar neuritis sometimes results, but in Graves' disease considerable exophthalmos can be present without the nerve being affected.

Causation.—Exophthalmos may occasionally be congenital [1] from want of development of the orbit, but, as a rule, is acquired and is then caused by injury or disease. It may be produced by deep-seated hæmorrhage, emphysema, foreign body, or other injury to the

[1] Power, *Trans. Ophth. Soc.* xiv. p. 212.

orbit, and in squint operations by free division of a rectus muscle.

It is a sign of Graves' disease and of irritation of the sympathetic. Locally, it is caused by cellulitis, periostitis, abscess, tumours, paralysis of the extrinsic ocular muscles, thrombosis of the cavernous sinus, and also by bulgings of the orbital walls from affections of the neighbouring cavities.

Enophthalmos is the term used to express recession or sinking of the eyeball into the orbit, and must not be confounded with microphthalmos. It results from paralysis of the cervical sympathetic when it is associated with contraction of the pupil, diminution of the palpebral aperture and increased perspiration of the same side of the face; loss of orbital fat in extreme emaciation and old age; hemiatrophy of the face; and also from traumatism [1] owing to fracture of the bones of the orbit or injury to other orbital structures.

ORBITAL INFLAMMATIONS.—The chief characteristics are varying degrees of exophthalmos, limitation of the ocular movements, and, except in cases of chronic abscess, swelling of the lids, congestion and chemosis of the conjunctiva. The seat of commencement is generally in the cellular tissue or in the periosteum; the exact diagnosis is often very difficult at first to make, but orbital cellulitis is the most common form.

Orbital cellulitis is an acute inflammation of the cellular tissue of the orbit, dependent on septic infection.

The *symptoms* and *signs* consist of the general phenomena of fever, and deep-seated, throbbing pain, which is increased by pressing the eye back into the orbit. The eyelids, especially the upper, are swollen, œdematous, and dusky-red in colour, and the neighbouring parts are involved in the swelling. The conjunctiva

[1] Lang, *Trans. Ophth. Soc.* ix. p. 41.

is congested, and often so greatly chemosed that the eyelids cannot be closed. The space between the orbital margin and the globe is occupied by a firm, tense and brawny swelling. The eyeball is gradually pushed directly forwards, and the ocular movements are limited in all directions. Inflammation of the optic nerve may be present, and optic atrophy sometimes ensues. The vision is usually impaired, and in some cases may be lost, especially in erysipelas. The disease is generally very rapid in its course, and may end in resolution; but, as a rule, it terminates in the formation of an orbital abscess, which points on some part of the upper lid near the orbital margin, or extends backwards to the brain, causing meningitis.

The *complications* are purulent uveitis with detachment of the retina, sloughing of the cornea, phlebitis of the cavernous sinus, or periostitis of the orbital walls.

Causation.—It has followed the presence of foreign bodies in the orbit; operation wounds, as excision of the eye and tenotomy; pyæmia and erysipelas; the spread of inflammation from the eyeball as panophthalmitis, or from surrounding parts as acute periostitis of the temporal fossa or irritation of a tooth.

It may be *diagnosed* from acute periostitis by the more general inflammatory swelling; by the restriction in every direction of the ocular movements; by the eyeball being pushed straight forwards; by the lesser degree of pain; and by the absence of tenderness on pressure on the orbital walls. The general constitutional symptoms, also, are more severe than in acute periostitis.

A favourable *prognosis* depends on the early evacuation of the pus. *Treatment* must first be directed to allaying the general symptoms by quinine; locally, the eye may be fomented or poulticed, and leeches applied to the temporal region. As soon as the presence of pus is suspected, an incision must be made through the lid or

conjunctiva with a narrow-bladed knife, which should be passed deeply into the orbit close to the orbital wall, and away from the eyeball. If pus be found, the symptoms are soon relieved, but even if it be not present, the free hæmorrhage from the incision will give much relief. After the incision has been made by the knife it is much safer to use a director or dressing forceps to search for the pus.

Periostitis of the orbit may occur as an acute or chronic disease.

Acute periostitis is generally limited, but may be diffuse; it has all the symptoms of cellulitis, from which, in its early stage, it is very difficult to distinguish.

The most common situation is the margin of the orbit, and a distinctive symptom is pain and tenderness on pressure on the orbital edges. The position of the inflammation may often be diagnosed by palpation, from the existence of a limited painful spot and by a feeling of fluctuation. In these cases, the exophthalmos is in a definite direction, as downwards or upwards, and the ocular movements are limited in the opposite direction to the displacement.

Diplopia is generally present. The optic nerve is not so often affected as in cellulitis, and the vision as a rule remains normal.

Periostitis involving the roof of the orbit is the most serious form as it may give rise to abscess of the brain.

The sequelæ are caries, necrosis, and orbital abscess. The prognosis is grave when the surface of bone affected is extensive.

The *treatment* consists of fomentations, and incision when the swelling is defined.

Chronic periostitis is the more common, and is generally of tubercular, syphilitic, or rheumatic origin. There is a localised irregular thickening about the anterior part of the orbital walls, with tenderness on pressure,

and deep-seated pain, which becomes worse at night. When deeply situated, there may be some exophthalmos, with paralysis of one or more of the orbital nerves.

In some cases, the periostitis may subside leaving generally a thickening (node); or suppuration may occur followed by caries.

In the tubercular form, there is nearly always suppuration and caries, with the formation of a sinus leading down to the disease, and afterwards, owing to the adherence of the surrounding parts to the bone, contractions involving frequently the lids and resulting in entropion.

In syphilitic cases, abscesses or caries are rarely met with; in the rheumatic variety, pain is the chief symptom, and visible signs of inflammation are rare.

Treatment.—Tubercular: general dietetic and hygienic remedies, such as strengthening food, cod-liver oil, sea air. Rheumatic: salicylate of soda, iodide of potassium. Syphilitic: large doses of iodide of potassium and mercury.

Caries of the orbit is generally the result of chronic periostitis, but may commence in the bone. Its usual situation is at the margin of the orbit towards the outer side, and its symptoms at first are those of orbital periostitis and abscess. After the abscess has burst a sinus is formed, discharging thin sanious pus, and having at its aperture a button of pink granulation tissue. The skin in the immediate neighbourhood tends to become involved, and from the contraction ensuing ectropion is often produced. It occurs, as a rule, in tubercular subjects, generally children, and is also a manifestation of tertiary syphilis.

Treatment must be directed in tubercular cases to improving the general health by change of air, &c.; in syphilitic cases by mercury and iodide of potassium.

The sinus should be syringed out with antiseptic lotions of carbolic acid, chloride of zinc, or corrosive

sublimate, and a drainage tube inserted; in very chronic cases, the sinus may be laid open, and the carious bone treated either by direct application of dilute sulphuric acid or by scraping with a small Volkmann's spoon. In caries of the roof of the orbit, operative procedure must be undertaken with extreme caution owing to the risk of meningitis.

Necrosis of the orbital bones is very rare and results from acute traumatic periostitis followed by abscess. When the dead bone has exfoliated, an incision should be made down to the sequestrum, which must then be removed with a pair of forceps.

Orbital abscess is either acute or chronic, and is the result of inflammation of some part of the orbit or its contents.

Cases of *acute abscess* when the suppuration is deeply placed in the orbit are very serious, and demand active treatment, as not only sight but life may be endangered.

The *symptoms* are those of orbital cellulitis, but the protrusion of the eye is generally downwards and outwards, or downwards and inwards, according to the position of the abscess. Fluctuation may be felt over the most prominent part of the swelling.

The *treatment* should be by incision at the spot where there is most swelling, even when no fluctuation can be detected; if pus is found, free drainage must be allowed.

The most common form of acute orbital abscess is a small collection of pus in the superficial connective tissue of the orbit. It is marked by swelling and redness of the lid, vascularity and chemosis of the conjunctiva, and pain on movement of the eyeball; but these signs are not accompanied by proptosis. These abscesses appear without any definite cause and are difficult to localise. The *treatment* should consist of hot

fomentations until the position of the pus can be made out, when it should be incised.

Chronic abscess of the orbit is most difficult to distinguish from a soft orbital tumour. The development is very slow and unaccompanied by pain, and the patient only comes for advice when there is protrusion of the eyeball or diminution of vision. The diagnosis should be made by exploratory incision into the swelling, and if pus be found the opening should be enlarged to ensure free drainage.

ORBITAL TUMOURS may either be primary, or secondary to growths elsewhere. The *primary* have their origin in the connective tissue, periosteum, sheath of the optic nerve, or lachrymal gland. The *secondary* invade the orbit from the neighbouring bones and cavities or from the eyeball, and are very rarely metastatic. They may be fluid or solid; if the former, they are nearly always in connection with the frontal sinus or ethmoidal cells and contain pus or mucus, whereas the solid ones are generally malignant.

The signs of an orbital tumour are slowly increasing proptosis, displacement of the eye downwards or upwards and to one side, restriction of the ocular movements mechanically or by direct implication of the muscles and nerves. One orbit only is usually affected, though both may be in lympho-sarcoma or exostosis. By palpation, the swelling may be diagnosed as to its situation, consistency, size, and mobility. It is very important to examine carefully the neighbouring cavities of the mouth, nose, and frontal sinuses for signs of implication. Owing to interference with the circulation, the palpebral and conjunctival vessels may be much dilated, and occasionally ecchymosis and chemosis of the conjunctiva may be present, though these last are more often the signs of inflammatory trouble. Pulsation, if present, should be detected by placing a handkerchief over the orbit and

listening with the ear or a stethoscope, and care should be taken not to confound it with the muscular sound of the orbicularis muscle.

The *symptoms* are pain, situated in or around the orbit and transmitted along the branches of the ophthalmic division of the fifth nerve; diplopia, due to the mechanical squint; dimness of vision often little marked in slow-growing tumours, though on the other hand sight may be quite lost from atrophy following optic neuritis.

Orbital tumours are divided into inflammatory and new growths.

Inflammatory.—*Non-infective granuloma* produced by a foreign body; an *infective granuloma* is syphilitic or tubercular, and chiefly found in connection with chronic periostitis.

New growths. Innocent.—The *cystic* are dermoid, meningocele, and, very rarely, encephalocele and hydatid.

Dermoid cysts are most often situated at the outer side of the orbit and are of congenital origin, though they may not be noticed before puberty, when owing to some irritation or growth, the secretive properties of the rudimentary epiblastic structure are rendered active. Their growth is very slow and they cause little inconvenience unless giving rise to proptosis. On palpation, they are soft, fluctuating, free and non-adherent to the skin like sebaceous cysts; occasionally they have processes passing deeply down into the orbit as far as the apex, whilst the bone is hollowed out in their vicinity. Their contents consist of sebaceous matter, small hairs and oil. Owing to their recurrence unless completely removed, they should be carefully dissected out entire, and the skin incision should, if possible, be parallel to the eyelid.

Meningocele is a rare congenital condition. It appears as a semi-translucent, fluctuating, and occasionally pulsating tumour at the inner angle of the orbit. The swelling can be diminished by pressure, and is increased

by strain or coughing. It is always connected with the bony walls of the orbit, in which a depression can be felt. It may be associated with hydrocephalus, spina bifida, or some other congenital affection, and no operative procedure is justifiable.

The *solid* tumours are exostoses, nævi, and, more rarely, lipomata and fibromata.

Exostoses are occasionally met with growing from the walls of the orbit or from the frontal or ethmoidal sinuses, and are situated generally at the inner side of the orbit; they grow very slowly, are often pedunculated, and may follow injury or be congenital. They are generally of the hard or ivory variety, but have sometimes a cancellous centre. Their *treatment* by operation is not without risks, and is accomplished by drilling the neck of the tumour and afterwards chiselling it through.

Malignant.—*Sarcoma* originates in the periosteum, the connective tissue, the lachrymal gland, eyeball, or optic nerve, and may also invade the orbit from the neighbouring cavities. Orbital sarcomata in the early stages occur as hard, firm, and fixed swellings, and as a rule may be felt at some part of the orbital margins. They gradually increase in size, and cause the usual symptoms of orbital tumour, but are accompanied by little local inflammation. They generally recur after removal, and eventually cause death by extension into the brain, or by visceral deposits. *Carcinoma* is only found as primary disease in connection with the lachrymal gland or the optic nerve, but may be secondary to disease of the eyelids or lachrymal passages.

Treatment.—Malignant tumours must be removed freely, even with the eyeball and contents of the orbit. In some cases, after the orbit has been cleared out and the hæmorrhage stopped by pressure, chloride of zinc paste (F. 47) on strips of lint may be plastered round the sides of the orbit, and the rest of the cavity filled up

with cotton wool. The effect of this treatment is that the periosteum, and frequently a layer of bone, exfoliate. This operation is always followed by severe reaction.

Pulsating exophthalmos.—A number of cases have been recorded in which extreme proptosis has been present accompanied by pulsation. The *symptoms* are noises in the head, tinnitus aurium and dizziness, but pain is generally absent.

The *signs*, besides proptosis, are a bruit heard over the eye, which is often stopped by pressure on the carotid; the pulsation is increased by leaning the head forwards; the proptosis can be reduced by pushing the eye backwards into the orbit. The *cause* may be aneurism of the ophthalmic artery or internal carotid, aneurism by anastomosis, varix, malignant vascular growths, or thrombosis of the cavernous sinus. The *diagnosis* between these diseases is very difficult, but in the case of a tumour the pulsation is much more difficult to control by pressure on the carotid.

Treatment.—In some cases spontaneous cure occurs, but as a rule compression or ligature of the carotid, or electrolysis, must be resorted to.

Distention of frontal sinuses (frontal mucocele) may be mistaken for an orbital growth, and is found as a localised fixed swelling at the inner side of the orbit. The frontal sinuses situated in the frontal bone consist of cells lined by mucous membrane, and divided more or less into two, right and left. Each communicates by the infundibulum with the middle meatus of the nose. The wall of the sinus next to the orbit is the weakest, and hence tends to give way on distention of the sinus. Generally the sinus is only affected on one side, and this may occur at all ages except in young children, in whom these structures are not developed.

Signs.—A fixed swelling at the inner part of the orbit, varying at times in size, and, if the wall has given way,

with a feeling of fluctuation over it; marked proptosis downwards and outwards. The swelling, as a rule unilateral, is generally of slow progress and very chronic; the contents consist of a glairy tenacious fluid or pus.

Symptoms: Diplopia is generally present, and there is often headache and pain over the frontal region. In some cases suppuration occurs, when considerable constitutional disturbance and pain ensues; the lids are red and œdematous, and the conjunctiva is chemosed.

Cause.—Generally a history of injury, which may have produced fracture of the cells and obstruction of the infundibulum. The effect of closure of this opening would be retention of the mucus discharged by the lining of the cells, which, gradually accumulating, would distend the sinus. Occasionally polypi from overgrowth of the mucous cells are found.

The *treatment* is by an incision through the skin into the swelling, and after the fluid is evacuated the cavity should be explored by the finger. A drainage tube must be inserted, and it is a good plan to bring the tube through the nose, so that afterwards the sinus may be properly drained, and any re-accumulation of fluid prevented.

INJURIES OF THE ORBIT.—These may be divided into non-perforating (contused) and perforating wounds, and are generally accompanied by hæmorrhage either immediately beneath the conjunctiva or deep in the orbit.

Subconjunctival hæmorrhage commonly occurs in the anterior part of the conjunctiva, and is due to the rupture of a small vessel. It often completely encircles the cornea, and seldom reaches backwards beyond the equator.

In fracture of the anterior fossa of the skull, hæmorrhage may take place beneath the posterior part of the conjunctiva; in these cases the anterior limit of the blood can usually be seen about the equator; behind, it is much more marked and intense in colour, and the posterior limit cannot be defined. The blood gradually creeps forward

and in the later stages resembles the hæmorrhage in the anterior part of the conjunctiva. Hæmorrhage into the deeper parts of the orbit occasionally produces proptosis.

Penetrating wounds of the orbit should never be lightly regarded, as it is difficult to ascertain the exact history of the injury, and severe damage may be done to the deep structures with scarcely any visible external wound. It is most important that the object producing the injury should be carefully examined, as a piece may have been broken off and remain in the orbit. A frequent cause is a thrust with a walking-stick or umbrella, and this may be followed by fatal results if the roof of the orbit be perforated. Other complications are injury to the optic nerve, rupture of a muscle, deep hæmorrhage, or emphysema from perforation of the ethmoidal cells.

Foreign bodies may lodge in the orbit, and when embedded in the fat can remain there without being discovered. A hat-peg $3\frac{3}{10}$ inches in length is perhaps the largest object ever known to have been so concealed.

Treatment.—The patient should be kept quiet after a penetrating wound, and symptoms carefully watched for. A foreign body should, if possible, be removed in all cases, owing to the likelihood of severe inflammation being set up by its presence. The ingenious method [1] invented by Mackenzie Davidson now enables its position to be accurately localised by the Röntgen rays.

Fracture of the walls may be caused by direct or indirect violence. The inner wall, being the thinnest, is the most often fractured, and this injury is accompanied by emphysema of the lids and orbital tissue. Fracture of the anterior fossa of the skull may involve the apex of the orbit, and be followed by immediate blindness, owing to injury of the optic nerve.

OPERATIONS.—**Excision** is the operation for complete

[1] *Brit. Med. Journ.* 1898, i. p. 10.

removal of the eyeball, and is indicated as a last resource in rupture of the globe, presence of a foreign body in the eyeball, painful blind eyes and malignant growths.

A general anæsthetic is necessary, but no special preparation of the patient other than that for the anæsthetic is needed.

The *instruments* are speculum (fig. 23), fixation forceps (fig. 19), a pair of small curved blunt pointed scissors (fig. 81), strabismus hook (fig. 93), and, lastly, a pair of large curved blunt pointed scissors (fig. 82),

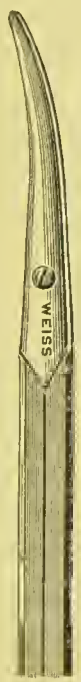


Fig. 81.—Small Curved Blunt Pointed Scissors

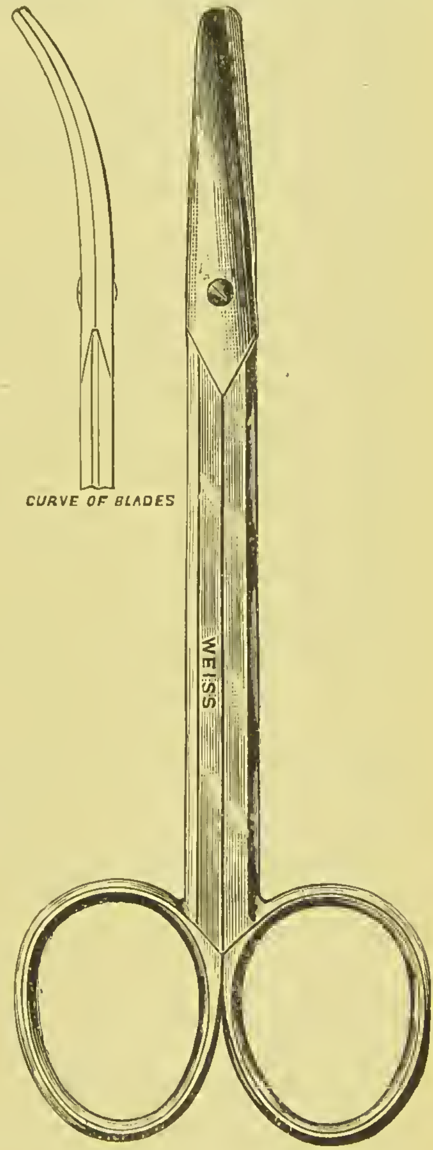


Fig. 82.—Large Curved Blunt Pointed Scissors

which may be used for division of the optic nerve. All instruments should be boiled immediately before the operation and then placed in weak carbolic acid solution (1 in 40).

Position.—The patient should be lying on his back with the head slightly raised and facing the light; the operator, standing behind the patient's head, has generally an assistant to hand the instruments and to sponge when necessary.

The operation.—The speculum being inserted between the lids, the conjunctival sac is irrigated with warm distilled water or boracic acid solution.

Division of conjunctiva.—The operator, holding the fixation forceps in his left hand and the scissors in his right, pinches up with the forceps a fold of conjunctiva at the right-hand side (temporal if right, nasal if left), near the limb and in the middle line. He makes a small opening in the fold of conjunctiva, and then, introducing one blade through this opening, he divides the conjunctiva the whole way round the corneal margin, and as close to the limb as possible. The complete division of the conjunctiva is one of the most necessary steps, and though it may be done in two or three cuts of the scissors, beginners usually find some difficulty.

The conjunctiva is now raised with the forceps, and the closed scissors being passed beneath it are used to separate it gently from Tenon's capsule.

Tenotomy stage.—The forceps are now exchanged for the hook, by means of which the operator raises the tendon of the external rectus, and divides it on the temporal side of the hook, so that the tendon is left with a long attachment to the globe. The other recti are then divided between the globe and the hook as close to the former as possible. It is important for neat operating, that the handles of the scissors and hook be always in opposite directions, so that in cutting the muscle the

tendon is not pushed off the hook. The hook is now again passed round the globe to ensure the recti and capsular attachments being completely divided.

Dislocation of eyeball.—The operator, holding firmly the portion of tendon of the external rectus by the fixation forceps, pulls forward the eyeball and rotates it inwards so that the nerve may be put on the stretch.

Section of optic nerve.—He then passes the large scissors closed, with their concavity towards the globe, from the temporal side, and with their closed points feels for the optic nerve, which can be recognised by the firm resistance it offers. Having felt the nerve, the scissors are drawn back slightly, opened, and the nerve is divided. The operator, still holding the globe by the forceps, draws it forwards and divides the obliqui and any fascial attachment with the scissors, and thus completes the operation.

Another method, after dividing the recti, is to press the speculum backwards into the orbit, when the globe will dislocate forwards, and, after dividing the nerve, the eyeball is taken between the finger and thumb of the left hand and the operation completed as above.

This description is for the right eye, and the only differences made in the case of the left eye are that the conjunctival incision is commenced on the nasal side, the internal rectus left long, and the nerve divided from the nasal side, and therefore, as in the right, everything is approached from the right hand of the patient.

Irrigation.—The speculum is removed and the orbit plugged for a few moments with a small sponge to control the hæmorrhage, which is seldom excessive. The orbit is then irrigated and the lids closed.

Dressings.—Graduated pads of absorbent cotton wool or gauze are applied with a firm bandage. It is seldom necessary to put a pad into the orbit, as the needful pressure can be applied through the lids.

Complications during operation.—The eye, from injury

or disease, may rupture, in which case the ruptured portion must be at once sutured, and the operation then proceeded with.

In cases of excessive hæmorrhage from the back of the orbit, the operation must be quickly completed, and the hæmorrhage controlled by carefully packing the orbit with graduated pads (the first, if necessary, may be wrung out in boiling water), combined with firm bandaging.

After treatment.—The patient can usually get up on the second day. The dressings are changed daily and reapplied in a similar manner for three or four days, when a simple pad and bandage are sufficient, till about the seventh day.

Remote complications.—After excision of a suppurating eyeball, there is a risk of *meningitis* following, generally about forty-eight hours after the operation.

A button of *granulation tissue* frequently appears at the junction of the conjunctival edges, and, if small, may be cauterised with nitrate of silver, but generally is best cut off with scissors under cocaine.

In some cases, especially where there has been much destruction of the conjunctiva, *cicatrices* involving the mucous membrane of the socket occur, and may prevent the insertion of a glass eye.

Entropion may follow from the upper lid having lost its support, and the lashes, turning in, by their irritation produce a discharge from the socket. This is best prevented by keeping in the orbit a small oval piece of absorbent wool smeared with vaseline, from the end of the first week till the artificial eye is worn, which should not be before the eighth week. The wool should be changed every day and should not be large enough to prevent the edges of the lids coming into contact.

When excision is done in young children, the deformity produced is always greater than in adults, owing to the fact that the orbit on the injured side fails

to grow (shrinking of orbit), and the face in consequence appears asymmetrical.

Evisceration is the removal of the cornea and contents of the eyeball, the sclerotic alone remaining. Under certain conditions it may be done as an alternative for excision, and when successful, has some advantages in its favour.

It may be performed in preference to excision in any cases except malignant disease, but the healing process is much more protracted.

Operation.—Instruments: Speculum (fig. 23), fixation forceps (fig. 19), a pair of curved scissors (fig. 81), a Graefe's (fig. 57) or Beer's knife (fig. 20), and a Mules' scoop (fig. 83). All the details of the operation down to the introduction of the speculum are the same as in excision. The conjunctiva is divided around the cornea with the scissors; the knife is introduced at the sclero-corneal junction on the temporal side, opposite the centre of the cornea, and a counter-puncture made at a corresponding point on the nasal side, and the knife is then made to cut its way out along the sclero-corneal junction above.

With the scissors the circle of the sclerotic is completed below.

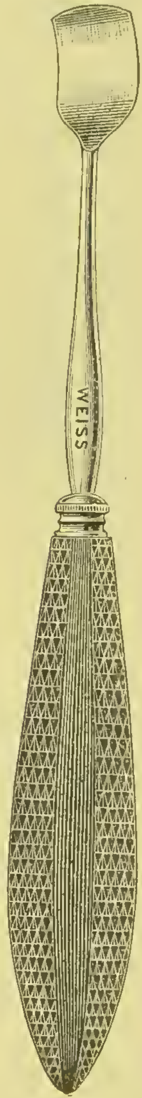


FIG. 83.—MULES' SCOOP

The contents of the globe are then removed by the scoop, care being taken to peel off the choroid so that only the sclerotic is left. The interior of the eyeball is washed out, and after all hæmorrhage has ceased the edges of the sclerotic are stitched together,

and the conjunctiva then united over it. In suppurative cases, the globe may be packed for twenty-four hours, after which the packing is removed and the sclerotic allowed to granulate up.

In Mules' operation,[1] a hollow glass ball is inserted into the scleral cavity after evisceration, and the sclerotic and conjunctiva sutured over it. There is always much chemosis and irritation for a few days after this operation ; if the sutures hold, the stump for an artificial eye is excellent.

Abscission, or removal of the anterior part of the eyeball, is sometimes performed for corneal staphyloma, especially in young children.

Operation.—The instruments required are a speculum (fig. 23), fixation forceps (fig. 19), Beer's knife (fig. 20), pair of curved scissors (fig. 81), three or four large curved needles threaded with catgut or silk. The details, as far as the introduction of the speculum, are the same as for excision.

The conjunctiva around the corneal margin is divided with the scissors, after which the anterior part of Tenon's capsule is separated from the sclerotic with the closed scissors. The needles are then passed singly and at regular intervals from above downwards through the sclerotic, about 2 mm. from the corneal edge, the counter-puncture below being at the same distance from the corneal margin. The point of the Beer's knife is introduced in the sclerotic about 3 mm. to the outer side, and opposite the centre of the cornea ; with the knife, or more easily with a small pair of curved scissors, the sclerotic is cut all the way round, about 1 mm. from the corneal margin, except at the inner side, where the incision must extend as far as on the outer.

This intervening portion, with the remains of the iris and lens if present, is now removed, together with any

[1] *Trans. Ophth. Soc.* vol. v. p. 200.

vitreous in front of the needles. The needles are passed completely through the lips of the wound from above downwards, the sutures tied and cut short, and the edges of the conjunctiva brought together over the stump.

The result is a movable stump for the artificial eye, but as it has in a few cases been followed by sympathetic ophthalmitis, the operation has fallen somewhat into disuse, and evisceration is probably to be preferred.

After all these operations, an artificial eye (fig. 84) is ordered when the socket is free from inflammation; but at the earliest this should not be before two months. The artificial eye should be taken out every night, and should be exchanged for a new one about every nine months, as the surface and edges become roughened. Very few people can bear the eye continuously for a long period, and whenever the socket appears inflamed, the eye must be discontinued for a time and boracic acid or other lotion used.

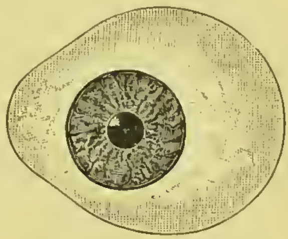


Fig. 84.—Artificial Eye

If the socket will not tolerate an eye of a size to correspond with the sound eye, this difference may be rendered less conspicuous by the patient wearing glasses with a convex lens on the side of the artificial eye.

CHAPTER XXI

AFFECTIONS OF THE OCULAR MUSCLES

Anatomy and physiology.—The extrinsic muscles of the eyeball consist of the four recti and two obliqui, which have their origin from the bony walls of the orbit and are inserted into the sclerotic. The recti (superior, inferior, internal, and external) are directed straight forwards, and arise by a more or less circular ring around the optic foramen, the external having a second head of origin from the lower margin of the sphenoidal fissure. In their direction forward, they form a muscular sheath for the optic nerve and the posterior part of the eyeball, being united together by the capsule of Tenon. The external and internal recti have a median insertion into the sclerotic, the external being situated farther back than the internal; the insertion of the superior rectus is somewhat oblique, and nearer the external rectus than the internal.

The superior oblique arising above the optic foramen passes to its pulley at the superior inner angle of the orbit, and then is directed outwards between the superior rectus and the sclerotic. The inferior oblique rises from the superior maxillary bone, and, passing below the inferior rectus, is inserted between the inferior and external recti.

The capsule of Tenon[1] or fascia of the orbit is divided

[1] Lockwood, *Anatomy of the Muscles, Ligaments, and Fasciæ of the Orbit. Journ. Anat. and Phys.* vol. xx. p. 1.

into an external and internal layer. The external gives prolongations to the extrinsic muscles, binding them together and attaching the internal rectus to the lachrymal bone, and the external rectus to the malar by the so-called check ligaments. A thickening of the capsule below forms the suspensory ligament of the eyeball. The internal layer surrounds the sclerotic, forming the external boundary of the lymph space separating it from the sclerotic, and thus forms a socket in which the eyeball can rotate without friction. The tendons of the extrinsic muscles pierce the internal layer immediately before their insertion into the sclerotic.

Nerve supply.—The superior, internal, and inferior recti and the inferior oblique muscles are supplied by the third nerve, and have their nuclear origin in the aqueduct of Sylvius. It is important to remember that the superior division of the third nerve supplies the superior rectus and the levator palpebræ, and that the inferior division, besides supplying the other muscles, gives motor nerves to the pupillary and ciliary muscles. The superior oblique is supplied by the fourth nerve from a nucleus in the Sylvian aqueduct below the third, and the external rectus by the sixth nerve, its nucleus being in the upper part of the fourth ventricle.

The ocular movements are represented in the frontal area of the cortex, and as yet have been found to be binocular.

Action of the muscles.—The eyeball is rotated round an immobile centre, one millimetre behind the centre of the eye, by its six extrinsic muscles. The initial position of the eye at rest is taken with the head erect and the eyes directed straight forwards and looking to a distant point. From this position, the muscles may be described as acting, either singly or in combination, by rotation round a vertical, horizontal, or oblique axis. The internal rectus rotates the eye inwards (nasal side) and the external

rectus outwards (temporal side). The superior rectus rotates the eye upwards and inwards, and the inferior rectus downwards and inwards. The superior oblique rotates it downwards and outwards and the inferior oblique upwards and outwards.

It will be seen from the foregoing that the direct external movement of the eye is by the external rectus, the internal by the internal rectus, the upward by the superior rectus and inferior oblique, and the downward by the inferior rectus and superior oblique. The intermediate movements are by combinations of the different muscles.

Field of fixation.—The limit of the different movements of the eyeball when the head is fixed is called the field of fixation, and can be best estimated by the perimeter (fig. 14). The patient is placed so that the eye, the movements of which are to be tested, is opposite the centre of the instrument, and, the arc being at first horizontal, he is told to follow the observer's finger as far as he can along it. Whilst he still fixes the finger, a candle is moved along the arc, and, when the corneal reflex of the flame is seen to be in the middle of the pupil, the number of degrees at which the candle stands is read off, and is the measure of the greatest movement in that direction. In the same way the extent of the movements is taken in the other directions. In the normal eye, it will be found to be 45° upwards, 55° downwards, 45° inwards, and 47° outwards.

Co-ordinated movements.—The actions of the muscles of the eyeball already described are for each eye singly, but after the early months of infancy the two eyes are associated in certain definite conjugate movements. These movements become involuntary, and it is very seldom and only after long practice, that a person can voluntarily move one eye without the other accompanying it. These co-ordinate or conjugate movements take place

either with the visual axes parallel to one another, or with the axes inclined towards one another and meeting at a point in front of the eye (convergence). The origin and reason for these movements are due to the desire for fusion and the maintenance of binocular vision.

Binocular vision is the faculty the eyes possess of working together in such a way that an object can be focussed on corresponding parts of each retina, and thus perceived as a single object by the brain.

In looking with both eyes at an object within the range of binocular vision, its image is received on the retina of each eye, and to be seen quite clearly it should fall on the macular region.

As has been already said, the parts of the retina of one eye are represented in the other eye by corresponding areas, and the stimulation of corresponding points in these areas, gives rise to a single sensation. The maculæ in both eyes are corresponding areas, and the right side of the yellow spot in one eye corresponds to the right side in the other. In the same way, the left sides correspond, and also the upper part of one to the upper of the other and the lower to the lower.

Tests for binocular vision.—The simplest test, which has also the great advantage of being applicable for distant or near vision, is to direct the patient to look at some print, and at the same time to hold a penholder vertically in the middle line a short distance in front of his nose. If he can now with both eyes open read the whole of the print, binocular vision is present; but if some of the letters or words are blotted out by the penholder, only one eye is being used.

Another test (Snellen's) is by means of a glass slide with transparent letters, alternately red and green. The patient, wearing spectacles with a red glass on one side and a green glass on the other, is directed to look at the slide, and if he reads all the letters his vision is binocular;

if using but one eye, he will only see letters of the colour corresponding to the glass before that eye.

Hering's test. The patient looks through a box shaped like a stereoscope, about 18 inches long, at a thin wire or string stretched horizontally across the end. Marbles are dropped close to the string, and the patient is asked, as each one falls, whether it is on the near or far side of the string. If using both eyes together, his answers will be correct, but if using only one eye, he will make frequent mistakes.

If a prism of 6° with the base outwards or inwards is placed in front of one eye, whilst the other is looking at an object, and the eye with the prism in front of it moves inwards or outwards without any movement of the other eye, binocular vision is probably present.

The parallel conjugate movements are lateral, vertical, or oblique, and may in consequence take place in every direction.

The vertical movements are effected by the same named muscles in either eye, and therefore the same nerves are brought into play. The elevation of both eyes brings into play the superior recti and the inferior obliques; their depression, the inferior recti and superior obliques. The horizontal or lateral movements are produced by the external rectus of one eye and the internal rectus of the other—that is, on looking to the right by the muscles on the right of each eye, and to the left by those on the left.

These lateral movements, which are the most used of the conjugate deviations, are effected by the co-ordination of the sixth nerve supplying the external rectus of one eye, and the third the internal rectus of the other. They have their centre in the cerebral cortex situated on the opposite side to the direction of the movements, and being the most powerful of the conjugate deviations, were the only ones noted till lately in experi-

ments on the cortex. Risien Russell [1] has, however, shown that other binocular movements, including convergence, are present, and can be evoked by stimulation of the cortex if the conjugate lateral movements are excluded.

The other associated movements are those of convergence, in which there is approximation of the visual axes in front.

Convergence is the power the eyes possess, by means of the internal recti, of taking up a position so that the visual axes may simultaneously impinge on an object in front of the eyes situated at a distance less than infinity. When the eyes are directed to an infinite distance, the visual axes are parallel (fig. 85, L P, R P′), and hence there is no convergence; but within this distance the nearer the object fixed is situated, the greater the effort of the internal recti.

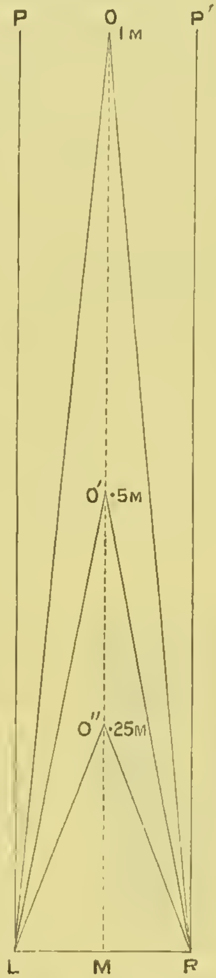


Fig. 85.—Diagram illustrating Convergence

L, R, left and right eye; L M R, base line or distance between the eyes; L P, R P′, fixation lines for parallel rays; L O R, convergence angle of both eyes for 1 metre; L O′ R, for ·5 metre, and L O″ R for ·25 metre.

When the eyes are directed to an object in the middle line, the convergence is effected, as a rule, by an equal contraction of each internal rectus, but if the eyes are turned sideways and then view a near object, the major

[1] 'Experimental Investigations of Eye Movements,' *Journal of Physiology*, xvii. p. 1 and p. 377.

part of the convergence falls on the muscle of one eye. The eyes naturally converge slightly on looking downwards, and diverge on looking upwards.

The visual axes meeting at the object form an angle called the angle of convergence (see fig. 85), and the amount of convergence power used can be measured by this angle. Nagel has arranged a scheme for measuring this power, and takes as his standard the metre angle (m.*a*.), which is the amount of convergence effected by each eye for the distance of one metre. This is a very convenient form, and brings the measurement of the convergence power into close relation with that of the accommodation; thus, a convergence for half a metre is denoted as 2 m.*a*., and for a quarter metre as 4 m.*a*. The association of convergence and accommodation is considered later on (p. 369).

The convergence power may be estimated by finding the strongest prism with base outwards which can be overcome without producing crossed diplopia, and this may be effected by a prism before one eye or weaker prisms before both eyes.

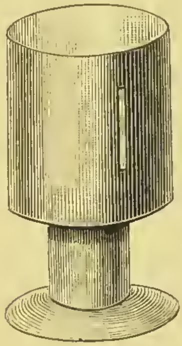


Fig. 86.
Ophthalmo-Dynamometer

A very convenient method is by means of the ophthalmo-dynamometer (fig. 86) of Landolt, which consists of a hollow metal cylinder arranged to fit on a candle; its sides are perforated by slits and rows of dots. To use the instrument, it is placed over a lighted candle and held immediately in front of the patient's face, and he is told to look at one of the slits and approach till he sees the slit double; this distance, read off on a tape measure, is the near point of convergence, and from the number of centimetres the metre angle is estimated. Thus, if he sees double at 10 cm., the amount of his convergence power 10 m.*a*. Another method is by Maddox rod test.

Most people have the power of slight divergence (*negative convergence*) in addition to positive convergence, and this can be measured by placing prisms before one eye, with their bases towards the nose, and ascertaining the strongest prism which the patient can overcome without diplopia.

A better plan is by Landolt's double prisms, as on this instrument is a scale marking the metre angles corresponding to the strength of the prism used. The usual amount is about 1 m.*a.*, and this, added to the positive convergence found, gives the amplitude of convergence. In a normal case, the positive would be 10 m.*a.* and the negative 1·5 m.*a.*, so that the total convergence would be 11·5 m.*a.*

Insufficiency of convergence power is frequently met with, and may amount in rare cases to total loss of convergence, though the lateral associated movements of the internal recti appear normal.

The *symptoms* are those of asthenopia (muscular)—namely, fatigue of the eyes for near work, diplopia, headache, neuralgia, and even vertigo. It can be diagnosed by measuring the amount of convergence by the ophthalmo-dynamometer (fig. 86), or, roughly, by making the patient fix the observer's finger, and noting, as it is approached to the eyes, the distance at which one eye gives up fixing and deviates outwards.

It is usually associated with myopia, but may be present in emmetropia or hypermetropia, and is found as a sequela of diphtheria and in anæmia.

Treatment.—In all cases the general health must be carefully attended to, and rest ordered for the eyes. Any error of refraction must be corrected, and in myopes the use of concave glasses for reading is generally advisable. Decentring the glasses, so as to give them a weak prismatic action, sometimes relieves the symptoms; if convex they should be decentred inwards, and if concave, out-

wards. In some cases, prisms with their bases inwards (towards the nose) may be ordered.

Failing these methods, recourse must be had to operation, either by advancing one or both internal recti, by tenotomy of the external recti, or by combination of tenotomy of an external rectus with advancement of an internal. For my own part, I much prefer advancement of an internal rectus to a tenotomy in these cases, but great care is necessary to ensure that the new attachment of the muscle should be correctly placed.

Strabismus (*στραβισμός*, squinting) or squint is the condition present when the visual axes of the two eyes are not directed simultaneously on the same object: thus, if one eye fixes an object, the visual axis of the other does not meet at the object (figs. 87, 88).

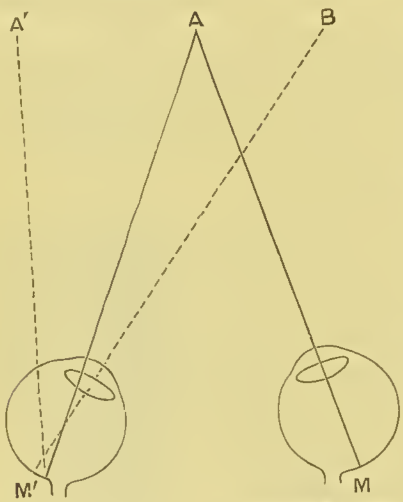


FIG. 87.—DIAGRAM ILLUSTRATING DIPLOPIA IN CONVERGENT STRABISMUS

The consequence of this condition is that the yellow spot region of both eyes does not receive the image of the object, and hence binocular vision is impossible and diplopia occurs. The diagram (fig. 87) shows the position of the double image in convergent strabismus. The right eye is fixing the object A, and its visual axis A M passes through the macula M and the object A. The left eye is squinting inwards, and its visual axis is directed M′ B. The object A will by the left eye be received on a part of the retina to the nasal side of the macula M′, and as this portion of the retina has been associated always with vision of external objects on the temporal side of the fixation point, therefore the object A is seen by the left eye

at A′, and thus diplopia is produced—the false image being to the left side of the object A seen by the right eye and therefore *homonymous*. As the false image falls on a part of the retina to the side of the yellow spot it is not seen as plainly as the true image in the right eye.

In external (divergent strabismus) (fig. 88) by the same reasoning the image of A in the left eye falls on the temporal side of the yellow spot, and is projected to the nasal side of the field—that is, towards the right, and hence the diplopia is *crossed*.

In similar way in an upward squint the false image is *below*, and in a downward *above*.

In all these cases, the greater the deviation of the eye, the farther apart the images and the less distinct the false image.

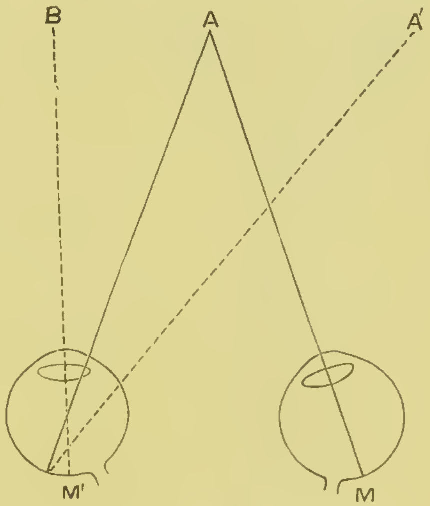


Fig. 88.—Diagram illustrating Diplopia in Divergent Strabismus

Diplopia (διπλόος, double; ὤψ, eye) is not always present in strabismus and is rarely so in concomitant cases that have lasted for some time, as the false image becomes suppressed. In extreme cases it is absent, probably from the false image being so faint.

Certain terms are used in connection with squint; thus the eye directed towards the object looked at is known as the *fixing* eye, and the eye deviating from the object is called the *squinting* eye.

In most cases, the patient uses the same eye always for fixation, and the amount of deviation in the squinting eye is then known as the *primary deviation*. If in such a case, the patient is made to fix an object with the squint-

ing eye, the original fixing eye deviates and this is called the *secondary deviation.*

Thus if a patient squints with his left eye, the primary deviation is in the left, and the secondary in the right.

Detection of squint.—In most cases it is obvious which is the squinting eye, but in others it is difficult, especially for beginners, to decide whether there is a squint at all, and if present, in which eye it is situated. The squint can be detected in the following manner: the patient is told to fix a small object held about 18 inches distant immediately in front of his face; the observer then holds a card in front of the apparently squinting eye, to satisfy himself that the uncovered eye is fixing the object; if the uncovered eye remains stationary no squint can be present in that eye. The other eye is now uncovered, and the patient again told to look steadily at the object; the card is then placed in front of the first eye and the second eye watched carefully for any movement; if it remains stationary there is no squint, but if the eye moves to take up a fresh position it could not have been fixing before, a squint is therefore present. If the movement was inwards the squint was of course divergent and *vice versâ.* Upon removing the card, the squinting eye in most cases will move back again to its original position, if not at once, certainly after winking, but in cases of alternating strabismus, the patient is able to maintain fixation in either eye.

Methods of estimating squint.—The amount of strabismus may be estimated in several ways, and it is important to remember that the head must be always kept erect, straight and motionless.

The simplest method is to make a mark on the lower lid of the squinting eye immediately below the centre of the pupil, and on now making the squinting eye become the fixing, a similar mark is made below the centre of the pupil, and the difference between these two marks is the

amount of the squint. This method is more easily carried out by means of the strabismometer (fig. 89), which is placed below the lower lid, and the amount of deviation read off.

The best method is to estimate the angle of the squint by means of the perimeter (fig. 14).

This is done by placing the patient in front of the perimeter, so that the fixing eye is in the middle of the instrument, and is looking in the direction of and beyond the white button. The quadrant is now adjusted in the line of vision of the squinting eye (with an internal squint it will be on the opposite side to the squinting eye and with an external squint on the same side). A small candle flame is moved along the limb of the quadrant, the observer keeping his own eyes in a line with the candle and the squinting eye. An upright image of the candle flame will be seen on the cornea of the squinting eye, and when this image is exactly in the middle of the pupil, the position of the candle on the quadrant is noted and the number of degrees read off; this is the angle of the primary squint.

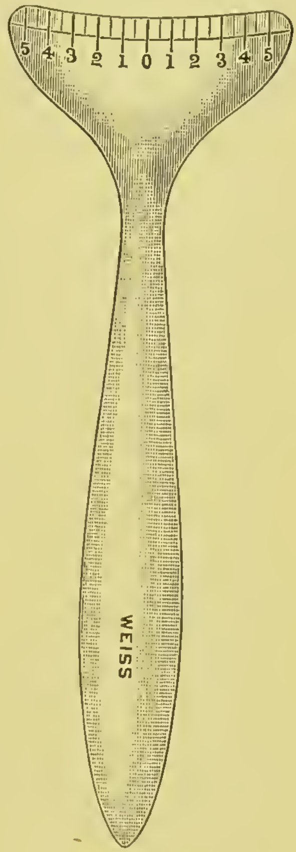


Fig. 89.—Strabismometer

The secondary squint can be estimated in a similar manner, but it is often difficult to obtain accurately owing to the patient's inability to fix the button of the perimeter with the primary squinting eye.

Squints may be divided clinically into paralytic and concomitant.

A **paralytic squint** is caused by loss of power, complete or partial, of one or more of the extrinsic ocular muscles owing to disease of the nerve supply, or to injury or interference with the action of the muscles, and is distinguished by the following symptoms.

The *primary* deviation of the affected eye is generally apparent, but may be only visible when movements are attempted in the direction of the paralysed muscle, and is exactly in the opposite direction to the normal action of that muscle.

The *secondary* deviation produced in the sound eye, when fixing with the affected eye, is always in the corresponding direction, and is greater than the primary one; this latter is one of the chief differences between a paralytic and a concomitant squint. It is due to the fact that the extra stimulus necessary to enable the paralysed eye to take up its position of fixation, being simultaneously transmitted to the associated muscle of the sound eye, produces an exaggerated action of this muscle, resulting in a greater degree of squint.

The defective movement of the eye is in the direction of action of the paralysed muscle.

Diplopia is nearly always present, and must be carefully mapped out.

Method of testing for diplopia.—The patient, seated in a chair, should be facing a candle placed on a level with his eyes at 3 metres distance, and should hold a piece of red glass in front of one eye. He is told to look at the candle, and if two images of the flame (one red and the other the usual colour) are seen, then by closing either eye, observing which image disappears and also the relative position of the images, the patient can inform the observer whether the diplopia is homonymous or crossed. He should then be asked how far the images appear distant from each other, whether they are on the same or on a different level, and also if they are erect or inclined. This

is noted down in the central space of a diagram composed of two vertical and two horizontal lines, forming nine spaces, as in fig. 91. The observer, standing behind the patient's head, moves it slightly to the right and then to the left, noting the images in the proper spaces in the diagram. In the same manner, raising the patient's head and afterwards depressing it, the diplopia is investigated in three positions above and three below.

Another and more usual method, giving the same results, is for the patient to keep his head fixed in one position, while the observer, holding a candle 3 metres in front of him, moves it in the nine positions, so that the diplopia is mapped as before.

The false image is situated in the direction of the normal action of the paralysed muscle, that is exactly opposite to the deviation of the cornea; it is homonymous (on the same side) if the false image is projected to the temporal side, and crossed if to the nasal side.

The distance between the images increases in the direction of action of the muscle paralysed, and diminishes, or is even lost, in the opposite direction.

Patients frequently keep one eye, as a rule the affected one, closed to avoid the diplopia.

Giddiness and unsteadiness of gait, if both eyes are open, may be due to the confusion produced by the double images, or to the false projection. These symptoms, however, probably result from the fact that the finely adjusted extrinsic muscles of the eyeball form one of the factors governing the equilibrium of the body, and hence can be produced by any upset of this equilibrium, as by paralysis of a muscle.

False projection is the erroneous perception the patient has of the relation existing between himself and surrounding objects, and is the result of the increased innervation distributed along the nerve of the paralysed muscle in the effort to make it work. It is equal to the difference

between the primary and secondary deviation ; thus, if the primary squint is 20° and the secondary 35°, the false projection is 15°. It is demonstrated by closing the sound eye and suddenly telling the patient to touch an object in front of him, when instead of doing this he will direct his finger to the side of the object corresponding to the paralysed muscle.

Inclination of head.—The patient turns his head in the direction of the paralysed muscle in order to avoid the discomfort of the diplopia.

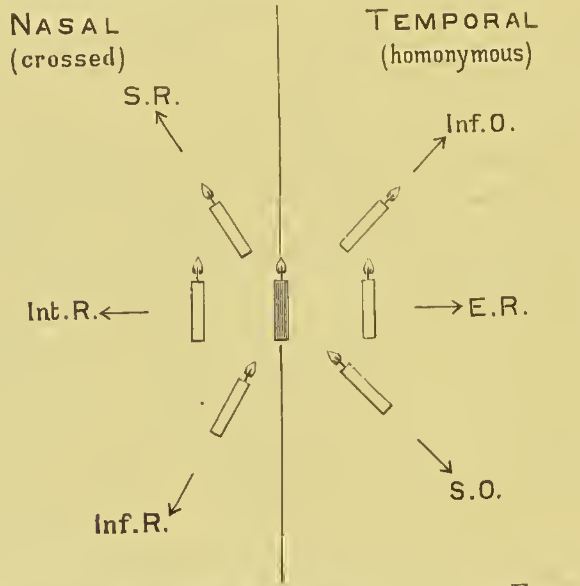


FIG. 90.—DIAGRAM SHOWING THE POSITION OF THE FALSE IMAGE IN OCULAR PARALYSIS. THE SHADED CANDLE IN CENTRE DENOTES THE IMAGE SEEN BY THE SOUND EYE, AND THE UNSHADED CANDLES THE FALSE IMAGES

S.R., Int. R., Inf. R., E.R., superior, internal, inferior and external recti ; S. O., Inf. O., superior and inferior oblique.

In the following descriptions the term 'paralysed side' is used to denote the side of the body corresponding to the affected eye, the opposite side being designated the 'sound side.'

Varieties of paralyses. *External rectus* (Sixth Nerve).—This is the most common of the ocular palsies,

probably from the long course of the sixth nerve. The signs are convergent strabismus and limitation of outward movement; homonymous diplopia, as in diagram (fig. 91 and 90 E.R.), the images being on the same level, erect and parallel, except above and below in the extreme of the field, and increasing in distance from one another as the eye is moved towards the paralysed side; the false projection is towards the paralysed side; the face is turned towards the paralysed side.

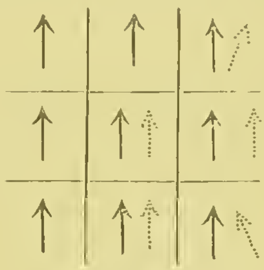


Fig. 91.—Field of Diplopia in Paralysis of Right External Rectus

Internal rectus.—The signs are divergent strabismus and limitation of inward movement (towards the sound side); crossed diplopia (fig. 90, Int. R.), the images being on the same level, erect and parallel, and undergoing greater separation towards the sound side; the false projection is towards the sound side; the face is turned towards the sound side.

Superior rectus.—The primary deviation is downwards and to the paralysed side, and the limitation of the movement upwards and to the sound side; crossed diplopia (fig. 90, S.R.) in the upper field, the false image being above the other, and inclined upwards towards the nasal side, the greatest separation being on looking upwards towards the paralysed side; the false projection upwards and towards the sound side; the face is directed upwards towards the sound side, and inclined towards the shoulder.

Inferior rectus.—The primary deviation is upwards and towards the paralysed side, and the limitation of the movement is downwards and towards the sound side; crossed diplopia (fig. 90, Inf. R.) in the lower field, the false image being below and inclined downwards towards the nasal side, the greatest separation being on looking

downwards towards the paralysed side; the false projection is downwards and towards the sound side, and the face is directed downwards towards the sound side, and inclined towards the shoulder of the paralysed side.

Inferior oblique.—The primary deviation is downwards and towards the sound side, and the limitation of movement upwards and towards the paralysed side; homonymous diplopia (fig. 90, Inf. O.), the false image being above the other, and inclined upwards and towards the temporal side, greatest separation being upwards and towards the sound side; the false projection is upwards and towards the paralysed side; the face is directed upwards towards the paralysed side, and inclined towards the same shoulder.

Superior oblique. Fourth Nerve.—The primary deviation is upwards and towards the sound side, and the limitation of movement is downwards and towards the paralysed side. Homonymous diplopia (fig. 90, S.O.) in the lower half of the field, the false image being below and to the paralysed side, and inclined downwards and to the sound side, the vertical distance between the images increased on looking down towards the sound side; the false projection is downwards and towards the paralysed side; the face is directed downwards and towards the paralysed side, and inclined towards the sound shoulder. The patient complains of great difficulty in walking, especially downstairs.

It will be seen from the foregoing that most of the signs are in the direction of the normal action of the paralysed muscle. These include the limitation of movement of the eyeball, the false image and increase in distance between the images, the false projection, direction of face, and inclination of the head.

In the opposite direction are only the position of the eye (squint) and the diminution or absence of the diplopia.

Paralysis of the third nerve is characterised by complete ptosis; on raising the upper lid there is divergent

strabismus with limitation of the upward, downward, and inward movements, and the eyeball is slightly protruded owing to the paralysis of the recti; the diplopia is crossed, the false image being a little inclined at its upper extremity to the paralysed side, the false projection is to the sound side, and the face is directed upwards towards the sound side and inclined to the shoulder of the paralysed side.

The other signs are moderate dilatation of the pupil, which is inactive to the light, accommodation, and sensory reflexes, and paralysis of accommodation.

Causation.—The exact lesion in ocular paralysis is frequently impossible to diagnose in the absence of other symptoms. Cases may be divided anatomically into (1) Cerebral, which may affect the nuclei of origin, the pontine fibres and their connection with the cortex (optic radiation); (2) basilar, involving the superficial origin of the nerves and their course within the cranium; (3) orbital, affecting the nerves or the muscles within the orbit.

The most common causes found in such cases are (*a*) Syphilis, in which any part of the tract may be affected. The paralysis occurs late in the acquired disease; a few cases in hereditary syphilis have been recorded; (*b*) it is frequently ascribed to gout and rheumatism, especially after exposure to cold and wet, and in the absence of symptoms pointing to other causes is then probably a peripheral neuritis; (*c*) anæmia and disorders of menstruation may also be a cause, in which case the position of the lesion can seldom be diagnosed; (*d*) post-diphtheritic paralysis of the extrinsic ocular muscles occasionally occurs.

A case may be diagnosed as cerebral when, with the absence of any obvious local or orbital cause, there are mental or other cerebral symptoms. The paralysis of the muscle is seldom so complete as in other cases, and more than one muscle is usually affected. The lesion may be due to tumour, hæmorrhage or softening, or the paralysis

may be a symptom occurring early in locomotor ataxy or at some period in the course of disseminated sclerosis.

The superficial origins of the nerves are often affected in diseases and injuries to the base of the skull, such as basal meningitis (tubercular most commonly), syphilitic periostitis of the base, gummata of the nerve trunks, aneurysm of the internal carotid in the cavernous sinus, thrombosis of the cavernous sinus, and injuries to the head involving the middle fossa of the base of the skull.

In the orbit the muscles, or the nerves supplying them, may be mechanically interfered with by inflammations of the orbital walls, syphilitic or rheumatic, and by other causes producing exophthalmos, such as deep-seated hæmorrhage, túmour, or Graves' disease.

A muscle or nerve is occasionally divided in perforating wounds of the orbit, and is often rendered functionless after fractures of the bony walls of the orbit.

Prognosis.—It must be borne in mind that in some cases spontaneous cure results, especially those ascribed to cold and wet.

In cases associated with syphilis or rheumatism, if the lesion be peripheral, treatment is generally followed by recovery, but there is a group of cases in which after complete recovery relapse occurs. The prognosis in central disease is not very favourable.

Treatment.—In syphilitic cases, mercury and large doses of iodide of potassium give good results; and in rheumatism, salicylate of soda or iodide of potassium should be given; in other cases nervine tonics, as strychnine and arsenic.

Local applications, as hot fomentations in rheumatic cases, blisters, leeches, are often indicated.

A shade may be worn over the affected eye, or in cases of partial paralysis, a prism correcting the diplopia in order to prevent the discomfort and danger of the double images. Electrical treatment sometimes gives good results, and the

best way[1] to apply it is to place the anode upon the nape of the patient's neck, whilst the operator, holding the cathode, uses his index finger covered by damp muslin as the active electrode. The current used is about 3 milliampères, and may be applied to the closed lid or to the conjunctiva over the muscle, cocaine having been previously instilled into the conjunctival sac.

Mechanical treatment by moving the eye backwards and forwards in the direction of the paralysed muscle by means of forceps, cocaine drops having been previously put in the eye, sometimes hastens the patient's recovery. Failing these methods, in cases that have lasted for some time, tenotomy of the opposing muscle, advancement of the affected one, or a combination of both operations may be performed.

Ophthalmoplegia externa is the name given to the condition in which all or nearly all the external muscles of the eye are affected with paresis, developing later into complete paralysis; the ciliary and pupillary muscles are unaffected. This disease, first accurately described by Hutchinson, is usually associated with syphilis and is invariably of nuclear origin. The lesion is situated below the aqueduct of Sylvius, and involves the nuclei of the oculomotor muscles. The escape of the nuclei of the ciliary and pupillary muscles is accounted for by the fact that they are situated farther forwards and have a different blood supply. In the early stages the paralysis is seldom complete. The symptoms are ptosis and limitation of movement of the eye in all directions, most marked in the upward movements. Both eyes may be affected, but it is usually a unilateral disease. Ophthalmoplegia externa is distinguished from total ophthalmoplegia by the absence of any loss of accommodation and pupillary paralysis.

The course is chronic and progressive, and beyond constitutional treatment little can be done for it.

[1] Buzzard: *Lancet*, 1875, ii. p. 485.

Concomitant strabismus is distinguished by the fact that the visual axes of the eyes, though not parallel to start with as in the normal eye, maintain the same relation to each other in all the conjugate movements of the two eyes. If the movements of each eye be observed singly it will be found that the actions of the different muscles are as a rule normal, and that there is no marked halting of the eye in any direction as in paralytic strabismus.

A concomitant squint is generally directly inwards (convergent) or outwards (divergent), but sometimes these main deviations are combined with a slight upward or downward tendency. It is not present at birth, and is never present in both eyes at the same moment.

Diagnosis from paralytic squint.—The movements of the squinting eye are not markedly impaired in any direction, though in some convergent cases there is a limited excursion ; the field of fixation is generally normal. The primary deviation is as a rule equal to, but is never less, or may be greater, than the secondary. Double vision is rarely complained of by the patient, and in consequence there is no particular inclination of the head or false projection, and the squint is never present in both eyes at the same time.

Convergent concomitant strabismus.—There are no marked *symptoms*, though occasionally in the early stages diplopia may be complained of.

The *signs* are deviation inwards of the visual axis of one eye and loss of binocular vision. The squint generally begins in early life, from the age of three to six years, as soon as the child fixes his attention on near objects, as small pictures, print, &c. There are some recorded cases of congenital squint, but these are very rare. Most children, whilst educating the eyes for binocular vision, squint at times, and this tendency is aggravated by any upset of the general health, as teething, but disappears in the majority of cases.

Varieties.—Squints are usually at first only visible at times, and are then called *periodic*; this form may be present in either eye and is generally most noticeable when the patient is out of health or is accommodating forcibly. It may disappear after a time, or lapse into the constant variety.

Constant squints are those which are always present, and may be divided into alternating and fixed. An *alternating* squint is one in which the patient fixes with either eye indiscriminately, and as a rule the vision is about equal in each eye; the greater number pass after a time into the next class (*fixed*).

A *fixed* squint is present when the patient of his own accord squints always with the same eye.

The acuity of vision in the squinting eye is generally much reduced and in many cases the eye is very amblyopic. Whether the amblyopia precedes and is the cause of the squint, or whether the squint produces the amblyopia, is one of the most debated questions in ophthalmology.

The great difficulty in its solution is the fact that the acuity of vision cannot be estimated in a very young child. The probability is that in most cases the amblyopia is congenital, as education of the squinting eye by keeping the sound eye closed has, as a rule, scarcely any effect on the acuity of vision.

Children, even at five years old, with fixed squint have often great amblyopia in the squinting eye. Cases are met with at times in which, though the eye has squinted for years, the vision has remained normal.

Causation.—In the greater proportion of cases (80 per cent.) hypermetropia is present, as Donders first pointed out. The reason is to be found probably in the abnormal association of the convergence and accommodation in hypermetropia. A young hypermetrope of 4 dioptres needs 4D of accommodation to see distant objects clearly. To enable him to see at 1 metre he would require 5D of

accommodation, which would normally be associated with 5 m.a. of convergence, and therefore he would be using 5 m.a. of associated convergence for seeing at 1 m., instead of 1 m.a., the usual amount. To avoid this abnormal condition, he must either give up some accommodation and only use the amount usually associated with the necessary convergence, and thus while maintaining binocular vision sacrifice distinct vision, or else he continues distinct vision by means of his accommodation and gives up binocular vision. The latter is the usual course, and the result of it convergent strabismus.

In slight cases, binocular and distinct vision, especially for distance, may be maintained by contraction of the external recti, but this is accompanied by marked asthenopic symptoms.

Other theories are the overbalanced muscular action (Schweigger) and innervation (Hansen Grut) of the internal recti over the external.

Convergent strabismus is found associated with corneal nebulæ, lenticular striæ, great difference in the refraction of the two eyes, and in these cases, the squint is generally fixed and the squinting eye is the one with the greater difference in refraction or imperfection of the media. More rarely, it is present in myopia and emmetropia.

Treatment.—In all cases the refraction must be estimated, and this should be done with the eyes under atropine so that the total error of refraction may be found. If hypermetropia, or hypermetropic astigmatism, is present, glasses should be ordered for constant wear, correcting if possible the whole refraction error. In slight cases, if the squint disappears under atropine, glasses will probably effect a cure, but in any case spectacles should be worn for some months.

In children under three years of age, glasses should rarely be ordered owing to the difficulty and danger attending their use, but after that age they should be worn at all events when looking at near objects as books,

or at meal-time. It is important when the squint is a fixed one, that the child's attention should be attracted as much as possible away from the affected side and that all pursuits requiring the use of the accommodation, as reading fine print, should be prohibited. The use of weak atropine drops once a day will keep the accommodation relaxed, and so indirectly minimise the convergent movements.

Tying up the non-squinting eye for an hour or so a day, and 'orthopædic' exercises by prisms or with the stereoscope, are useful adjuncts to the treatment. If these measures do not result in marked improvement after persevering with them for at least six months, the question of operative procedure must be considered, though not as a rule before seven years of age.

In the alternating variety without marked amblyopia, binocular vision and permanent cure of the squint may result from a careful adjustment by operation. In fixed squint with amblyopia, as it is impossible to give binocular vision, an operation can only improve the appearance of the patient.

The operations are either tenotomy (limited or free) of one or both internal recti, advancement of one or both external recti, or a combination of both kinds of operations. It must be remembered that advancement of a muscle interferes much less with the normal position of the eyeball than tenotomy, which may be followed by proptosis, and I am thoroughly in favour of advancement in cases of slight degrees, especially when there is a weakening of the excursion on one side.

In convergent squint, the rule till lately was to divide the muscle on the squinting side, owing to the idea that the squint was produced by over-action of this muscle, due to hypertrophy, or to its possessing a better position for its action. In many cases also the internal rectus on the opposite side was divided at the same time. When both muscles were simultaneously divided, as a rule, after a year or so one eye squinted in the opposite

direction, and in consequence this procedure has now been dropped. Though in most cases there is no weakening of the action in the opposite direction, yet in others, especially of convergent squint, there is a limitation.

Every case before operation must be treated on its own merits; the refraction must be carefully worked out and glasses ordered, and the excursion and incursion of each eye taken. When there is a limit to the movement of the eye in the opposite direction to the squint, undoubtedly advancement will be the proper operation, as tenotomy does not necessarily increase the movement in the opposite direction.

It must always be borne in mind that advancement is much more under the operator's control than tenotomy, and that it seems more reasonable to operate in a fixed squint by the combination of a tenotomy and advancement on the affected eye, than by tenotomy on both eyes.

The advantages of tenotomy are that the operation is easily and quickly performed, that there is no pain and little discomfort afterwards, and that the eyes need only be bandaged for a few hours. The disadvantages are that the result is obtained by weakening a muscle, and that this weakening may be progressive.

The advantages of advancement are that it is strengthening a muscle by bringing forwards its insertion, and that the result is more under the operator's control. The disadvantages are that the operation is more tedious, and the patient is subjected to longer convalescence and more discomfort and pain. The estimation of the result likely to be obtained by operative treatment varies greatly, but the following rules may serve as a rough guide (the angle of squint is in every case estimated under atropine). With normal excursion and incursion of the muscles, a squint of 5° to 10° may be cured by a limited tenotomy of one muscle or advancement of the opponent; one of 10° to 15° by a free tenotomy on one side; 15° to 20° by a free

tenotomy and advancement of the opponent muscle, or by advancement of both opponent muscles; 20° to 30° by free tenotomy of one muscle, followed if necessary after a time by a tenotomy on the opposite side; and over 30° by free tenotomy on one side, always succeeded by tenotomy on the opposite side, or by free tenotomy on one side and advancement of the opponent muscle on both sides.

After-treatment.—The day after a tenotomy operation, the patient should be tested for double vision, which will be probably found, unless the eye is very amblyopic. The diplopia should be mapped out, and tried again a few days after. Prisms combined with the spectacles may help either to diminish or to increase the result.

In cases where there is good vision in either eye, occasionally binocular vision may be restored, and this is much aided by stereoscopic exercises (see Appendix).

Divergent concomitant strabismus. *Signs.*—Deviation outwards of the visual axis of one eye, and loss of binocular vision. The condition is rarely met with in very young children, and in this way differs from convergent strabismus.

The most common cause (60 to 70 per cent. of the cases) is myopia, and the greater the degree of myopia the more likely is it to be associated with divergent strabismus. This shows a marked distinction from the convergent strabismus associated with hypermetropia, which is less commonly met with in high degrees.

In the normal eye, accommodation is always associated with convergence (p. 369), whereas in myopia of medium and high degrees no accommodative effort is necessary, whilst the convergence must in the high degrees be excessive owing to the approximation of the far point to the eyes. It is evident that the internal recti in these cases of myopia have to work without the stimulus which is always present when the accommodation is in action, and there is in consequence a tendency to relax the internal recti.

This can be shown in most myopes by telling them to fix a near object when, upon covering one eye, the internal rectus of this side will relax and the eye wander out, showing that the desire for binocular vision is only just sufficient to maintain the visual axes in their proper position.

Asthenopia resulting from attempts at sustained convergence, which is also rendered difficult by the increased length of the eye, nearly always precedes the divergent strabismus.

A patient soon finds that by covering one eye with his hand he can read for long periods with comparative comfort. Very soon he will be able to suppress the image formed by this eye, so that there will be no need to cover the eye.

The strabismus will now be present for near objects, but later will progress till finally it will be present for distant vision as well.

A predisposing reason for its occurrence in myopic eyes is the increase in length of the bony orbits the axes of which naturally diverge, and the egg-shaped eyes would tend to coincide with the long axes of the orbits.

Divergent strabismus is found where, from disease or injury of one eye, binocular vision is no longer possible, and the eyes therefore have no need of convergence. This form of strabismus resulting from disease is found in blind eyes, corneal nebulæ, cataract.

As an after-result of tenotomy of the internal rectus it is met with owing to the weakening and stretching of the divided muscle. This was formerly more often seen when very free division of the muscle was done, or both internal recti divided at one sitting.

When divergent strabismus is developed, the only successful *treatment* is by operation. This may be effected by tenotomy of one or both external recti, but the result is not generally satisfactory, as division of the external recti, as a rule, is followed by little effect. Advancement of one or both internal recti gives the best results, as the

causation is due rather to the weakness, especially in the position of attachment, of the internal recti than to the strength of the external.

OPERATIVE TREATMENT consists in either weakening the muscle acting in the direction of the squint by division of its tendon (*tenotomy*), or in aiding the opponent muscle by bringing forward its attachment to the sclerotic (*advancement*).

Tenotomy should rarely be performed before the age of seven years, and as a rule on only one muscle at a time, as the after-effect is difficult to gauge, and it is much more satisfactory to obtain too little than too great result. It must always be borne in mind, that it takes months or even years for the full effect to be reached, and divergent squint, occurring some years after tenotomy of the internal recti has been frequently seen, under the old methods of dividing both muscles or the freer division of the muscles.

As the operation is a painful one a general anæsthetic, as chloroform, is needed in young children, but in adults local application of cocaine or eucaine is generally sufficient. No preparations are necessary beyond those usual for a general anæsthetic, except that in convergent squint it is often advisable that the eyes should be under atropine to aid the result by diminishing convergence through paralysis of accommodation.

FIG. 92.—STRAIGHT BLUNT - POINTED SCISSORS

Tenotomy of right internal rectus. — *Instruments.* — Speculum (fig. 23), two pairs of fixation forceps (fig. 19), a pair of straight (fig. 92) or curved (fig. 81) blunt-pointed scissors, and a strabismus hook (fig. 93); these instruments should be boiled immediately before the operation.

Position.—The patient should be in the recumbent position, and the operator should stand in front and on the right hand of the patient.

Subconjunctival or Moorfields operation.—The speculum being introduced between the lids, the conjunctival sac should be washed out with distilled water. The operator, holding a pair of fixation forceps in either hand, draws the eye directly towards the temporal side by the forceps in his right hand, and then seizes a small fold of conjunctiva, situated about the junction of union of the lower horizontal and inner vertical tangents of the cornea, with the forceps in his left hand. Taking the scissors in his right hand, he then divides the fold of conjunctiva so as to admit the points of the scissors, which should then divide the subconjunctival tissue to a slight extent. He now lays down the scissors, and taking up the squint hook passes it into the wound with the point directed backwards ; by a turn of the handle to the right the hook is passed beneath the tendon until its point is seen through the conjunctiva at the upper border of the muscle. The hook is now transferred to the left hand, and the scissors, taken in the right hand, are introduced through the wound so that they lie between the sclerotic and the hook with a blade on each side of the tendon, which is now divided by small cuts. After the tendon is divided, the hook is removed and reinserted in the wound to make sure that no portion of the tendon is left undivided; if the division is complete, the hook can be

FIG. 93.—STRABISMUS HOOK

advanced to the limb of the conjunctiva, and should then be covered only by conjunctiva.

Graefe's operation.—The first steps are the same as in the preceding operation, the only difference being that the conjunctival incision is made about 2 mm. from the corneal edge and opposite the middle of the muscle. After the subconjunctival tissue is divided by the scissors, the hook is inserted, and the muscle lying on it is exposed through the wound and then divided.

A third method (*Landolt's*), in which the tenotomy hook can be dispensed with, is especially useful when a small effect is desired, as the amount of division of Tenon's capsule can be easily regulated.

Instruments.—Speculum (fig. 23), pair of tooth forceps slightly curved at the end (fig. 94), and a pair of curved scissors (fig. 95).

Operation.—A fold of conjunctiva is fixed by the forceps held in the left hand immediately in front of the middle of the tendon, and a small incision made in the conjunctiva and capsule of Tenon by the scissors. The forceps are then introduced through the wound, and the tendon, being seized by them, is drawn forwards and divided by the scissors. If desired, a hook (fig. 93) can now be introduced and the structures more freely divided.

In all these operations, if the external rectus is to be operated on, it must be remembered that its insertion is farther away from the cornea than the internal, and the conjunctival incision should therefore be about 3 mm. from the corneal edge.

On completion of the operation, if the patient is not under a general anæsthetic, the result should be examined, and the operator may lessen the effect produced if necessary by suturing the conjunctival wound, or may increase it by dividing freely the capsule of Tenon near the tendon, or by rotating the eyeball forcibly by the forceps in the opposite direction to allow the tendon to slip backwards.

After-treatment. Immediate.—The conjunctival sac should be washed out and both eyes bandaged up till the

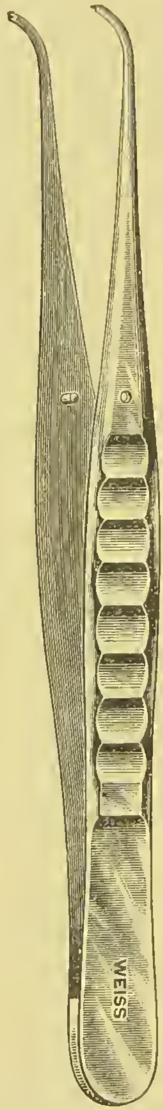


FIG. 94.—LANDOLT'S STRABISMUS FORCEPS

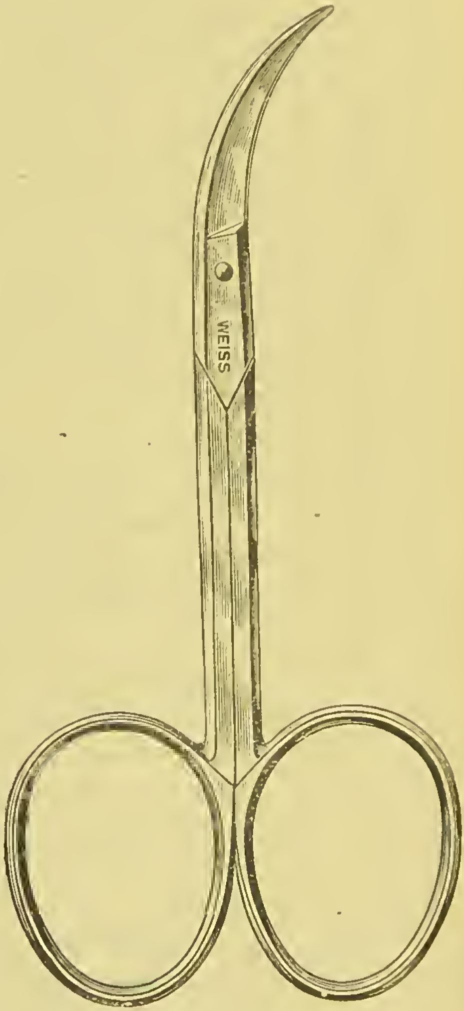


FIG. 95.—LANDOLT'S STRABISMUS SCISSORS

next morning, when the bandages may be left off altogether. The eye will be found to be bloodshot and will remain so for about ten days.

If the squint is either corrected or over-corrected, atropine should be discontinued, but if it is under-corrected atropine must be continued for some days, and if the patient is hypermetropic, glasses completely correcting the refraction error must be worn constantly for a time.

After-effects.—There is very seldom any great reaction or inflammation after the operation, and the complications are very few. A slight deformity is often caused by the sinking of the caruncle from free division of Tenon's capsule; this is rarely very noticeable, but if so may be remedied by detaching the conjunctiva from the subjacent tissue and stitching it up.

Occasionally a granulation grows from the wound and should be cut off.

The ultimate effect of the operation is generally greater after some weeks.

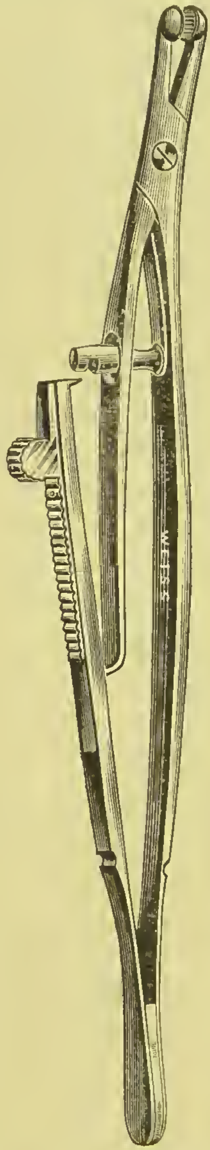


Fig. 96.—Needle-Holder

Advancement of the right external rectus.—A general anæsthetic, as chloroform, is as a rule necessary, though in some cases cocaine or eucaine may be employed.

Instruments.—Speculum (fig. 23), fixation forceps (fig. 19), tenotomy hook (fig. 93), pair of small straight scissors (fig. 92), three small curved needles, each threaded with fine silk, and a needle-holder (fig. 96).

Position.—The patient should be lying on an operating table, and the operator should stand behind his head with an assistant facing him on the left-hand side.

Operation.—The speculum being introduced and the eye well irrigated with distilled water, the operator seizes the conjunctiva with the forceps about 2 mm. from the corneal margin and in a line with the centre of insertion of the external rectus.

He now divides with the scissors the conjunctiva vertically to the extent of 5 mm. above and below the point of fixation, and afterwards the subconjunctival tissue and capsule of Tenon, and by this means exposes the tendon. The tenotomy hook is introduced at the lower border of the tendon, and passed beneath it till its point is brought out at the upper border; the tendon thus is exposed on the tenotomy hook, which is given to the assistant to hold. A needle, held by the needle-holder, is then passed vertically through the middle of the tendon, and the suture tied tightly in a knot; the needle is then carefully passed through the episcleral tissue and conjunctiva, and brought out about 1 mm. from the cornea. The tendon can now be cut away from its insertion into the sclerotic, and if desired a piece of it can be cut off. The suture is now tied tightly, bringing the tendon up towards the cornea. A second suture is introduced through the upper border of the tendon, passed through the episcleral tissue and conjunctiva above, and parallel with the original suture, and then tied. In the same manner the third suture is inserted and tied below. The conjunctival wound is now stitched together, the speculum removed, and the eye washed out, and a bandage applied over both eyes.

The eyes should be kept bandaged for a week and dressed every day. The stitches should not be taken out for a week at least, unless they are causing much irritation.

Nystagmus (νύσταγμα, sleep) (*involuntary oscillation of the eyeball*) is generally binocular, permanent, and associated with serious defect of vision. The movements are as a rule horizontal or rotatory, but may be vertical, and when present in both eyes are similar in duration and frequency. It may be constant or only when the eyes are moved in certain directions, and it always ceases during sleep.

When occurring in adults [1] patients are much troubled by the oscillatory movements of objects, but when the nystagmus dates from early life this symptom is not complained of.

Most cases date from infancy owing to some defect in the coats or media of the eye, such as opacities of the cornea or lens, choroidal or retinal disease, or albinism, and are then due to the defective vision preventing proper co-ordination of the ocular movements. In more mature life, it may follow chronic otitis and nerve diseases as disseminated sclerosis, hereditary ataxy, meningitis, hæmorrhage, softening and tumour of the brain. It is also found in coal-miners,[2] where it is probably due to the strain on the ocular muscles induced by looking obliquely upwards whilst using the pick in a lying position; and perhaps also to working with insufficient illumination. In these cases the condition generally disappears on giving up the work, but in others, treatment is of no avail.

[1] *Trans. Ophth. Soc.* vii. p. 264.

[2] Snell: 'Miner's Nystagmus and its Cause,' *Trans. Ophth. Soc* vol. iv. p. 315.

CHAPTER XXII

REFRACTION AND ACCOMMODATION [1]

Definition.—By the refraction [2] of the eye is meant the changes which the different transparent ocular media exert upon rays of light passing into the eye (in the normal state through the pupil) prior to impinging on the light-percipient portions of the retina.

The refraction refers to the effect produced on rays of light by the dioptric apparatus of the eye, and bears no relation to the acuity of vision ; it must be remembered that normal refraction may be present in an eye almost or completely blind from disease of the optic nerve or of the transparent media.

Optical Properties of the Eye.—Before proceeding to describe the refraction of the eye, it is necessary to state a few principles regulating the passage of light through the transparent media. The eyeball is a closed

[1] *The following abbreviations are used in this Chapter :—Em., emmetropia ; H., hypermetropia ; H.m., manifest hypermetropia ; H.l., latent hypermetropia ; H.a., absolute hypermetropia ; My., myopia; As., astigmatism ; Pr., presbyopia ; P.r., punctum remotum or far point ; P.p., punctum proximum or near point; Acc., accommodation ; M.a., metre angle ; D., dioptre ; V., vision ; lenses, + convex, − concave, Sph., spherical, Cyl., cylindrical, and* $\updownarrow$ *axis* of cylinder.

[2] Refraction is too large a subject to be more than cursorily dealt with in such a work as this, and the reader is referred to Ganot's *Physics*, Landolt's *Refraction and Accommodation of the Eye*, Donders' *Anomalies of Refraction and Accommodation*, Hartridge's *Refraction of the Eye*, and Morton's *Refraction of the Eye*.

chamber surrounded by a protective coat consisting of the cornea and sclerotic, and may be likened to a photographic camera filled with fluid, the retina corresponding to the sensitive plate.

A ray of light in its passage through the eyeball, until it reaches the light-percipient portion of the retina, traverses in order the following structures:

The layers of the cornea; aqueous humour; anterior capsule, substance, and posterior capsule of the lens; hyaloid membrane, vitreous, hyaloid membrane; layers of the retina.

In its passage through these structures the ray is deflected or refracted when traversing media possessing differences in their indices of refraction.

For practical purposes, the refractive indices of the cornea, aqueous, and vitreous may be taken as the same, and the only transparent ocular medium exhibiting a marked difference is the lens, which has a higher index than the others.

For these reasons, the chief deviations in direction of the ray take place at the anterior surface of the cornea and at both surfaces of the lens.

The greatest of these deflections occurs at the anterior surface of the cornea, as the ray here passes from the rarer medium air to the denser cornea and is consequently bent towards the normal (perpendicular to the surface), and this primary deflection is increased by the spherical surface of the cornea. At the anterior surface of the lens a further deflection takes place as the ray passes from the aqueous to the denser lens; at the posterior surface of the lens the normals are diverging and, as the vitreous is less dense, the ray will be bent away from these normals; the deflection will consequently still be in the same direction.

The transparent ocular media (cornea, aqueous, lens and vitreous) constitute the *dioptric apparatus* of the eye, and these taken together consist of a convex surface

separating the air from the more refractive ocular media and the convex lens. The aim and effect of this dioptric apparatus, therefore, is to form a collecting system like a magnifying glass or bi-convex lens, and thus to make the rays convergent and form a real image.

For the sake of simplicity, the refractive properties of the human eye may be represented by a convex lens of 23 mm. focus, and, as in the diagram (fig. 97), it will be seen that the parallel rays passing through the lens L are brought to a focus at Em., 23 mm. behind the lens on the principal axis, XX, of the lens. Convergent rays (C) would be focussed at H., in front of Em., and divergent (D) at My. behind Em. The diagram will therefore give an idea of a Hypermetropic, Emmetropic, and Myopic eye, as far as the relation of convergent, parallel and divergent rays to the respective retinæ H., Em., My.

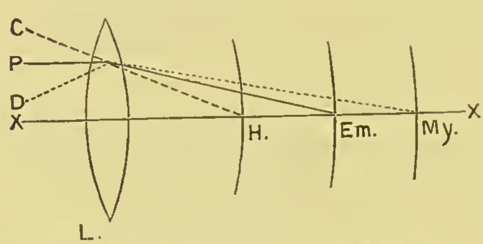


Fig. 97.—To illustrate Errors of Refraction

The diagram (fig. 98) shows the position in the normal eye of the cardinal points and the more important axes.

The *nodal point* (N) may be considered as situated at the posterior pole of the lens, though strictly speaking there are two nodal points, one in front and the other behind N. It may be taken as the optical centre of the eye, and rays passing through this point are not refracted and form secondary axes.

The *centre of rotation* (R) of the eye is 13·5 mm. behind the cornea.

The *optic axis*, XX, is the imaginary line passing through the centre of the cornea and the nodal point, and if projected backwards falls to the inner side of the macula M, and between it and the optic disc.

The *visual axis*, MNO, is the line joining the object looked at O with the macula, passing through the nodal point N.

The *line of fixation* RO, joins the centre of rotation R, and the object O looked at; it corresponds for practical purposes with the visual axis.

The angle, ORX, formed by the line of fixation and the optic axis, is known as the angle γ, and varies with the refraction of the eye; in Em. it is about 5°, but is larger in H., and smaller in My. In My. the angle may be absent, the line of fixation coinciding with the optic axis, or even be negative to it, the line of fixation falling to the temporal side of the optic axis. These variations of the angle γ give rise to apparent squints.

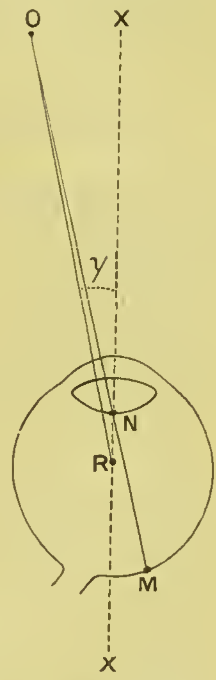


FIG. 98.—CARDINAL POINTS AND AXES OF EYE

The angle γ must be distinguished from the angle α, which is formed by the visual axis and the major axis of the corneal ellipse.

REFRACTION OF THE EYE.—This subject is considered in two parts:—*Static refraction* (commonly called refraction), in which the eye is in a state of rest, the accommodation being completely relaxed, and *dynamic refraction* or accommodation.

Refraction (*static*) *of the eye.*—All eyes, as far as static refraction is concerned, may be divided into two groups:—(1) Emmetropic; (2) ametropic.

(1). The emmetropic (ἔμμετρος, in measure; ὤψ, eye) eye (fig. 99) is taken as the standard, and is that in which parallel rays of light are brought to a focus on the retina, and divergent rays behind the retina.

2. The ametropic eye (α, not; μέτρον, measure; ὤψ,

eye), in which parallel rays of light are not brought to a focus on the retina, includes hypermetropia, myopia, and astigmatism.

The order here followed is first to describe normal refraction and accommodation, and then the errors of refraction and accommodation.[1]

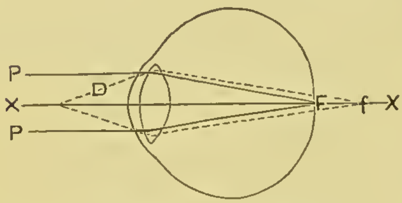


FIG. 99.—EMMETROPIA

Emmetropia or normal refraction is present in an eye (fig. 99) when, with the accommodation completely relaxed, parallel rays (P) are brought to a focus (F) on the retina, and divergent rays (D) behind the retina at (f).

Emmetropia, in the strict acceptation of the term, is rarely met with.

As a rule, the emmetrope should not complain of *symptoms* indicative of ocular strain or trouble.

Signs. — *Subjective.* If the transparent media be healthy, the vision should be at least $\frac{6}{6}$, and made worse by placing in front of the eye a $+ \cdot 5$ D. sphere. Under atropine, the vision should still remain $\frac{6}{6}$, or be but little altered.

Objective (accommodation preferably paralysed). *Ophthalmoscope. Direct distant.*—Only the red reflex is seen, the details of the fundus being invisible.

Retinoscopy.—With the concave mirror held at 1 metre distant, the shadow moves faintly against, and is corrected by a weak + glass.

[1] It must be remembered that in the following descriptions the eye is assumed to be normal, except so far as the refraction is concerned.

Direct close.—The details of the fundus are seen distinctly without a lens in the sight-hole, and become blurred by putting up a + ·5 lens.

Indirect.—No alteration in the apparent size of the image is caused by moving the lens to and fro.

Diagnosis.—If the eye is under atropine, this is easily arrived at by retinoscopy and the direct method.

Distant vision being perfect, neither myopia nor astigmatism can be present, and as the vision is made worse by + glasses, hypermetropia must also be absent, and therefore the eye is emmetropic.

Emmetropia may exist with diminished distant vision ($\frac{6}{18}$, $\frac{6}{12}$, $\frac{6}{9}$) in cases where there is spasm of accommoda-tion, but this disappears under atropine.

Dynamic refraction or accommodation is the power which the eye is able to exert, by means of the ciliary muscle, of increasing the convexity of the lens, and, by this means, its refractive power.

In an emmetropic eye (fig. 99) at rest, parallel rays (P) are brought to a focus (F) on the retina, whilst diverging rays (D) or those coming from a near object are focussed (*f*) behind the retina. Now if the refractive power of the eye is increased by the accommodation rendering the lens more convex (fig. 100), these divergent rays (D) can be brought to a focus (*f*) on the retina, whilst the parallel rays (P) are focussed (F) in front of the retina, and consequently distant objects will appear blurred during the act of accommodation.

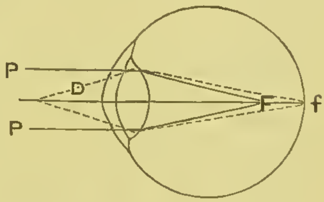


Fig. 100.—Emmetropia Accommodating

The usually accepted theory for accommodation is that the ciliary muscle by its contraction pulls forward the choroid and relaxes the suspensory ligament of the

lens; by this means the convexity of the whole lens is increased chiefly at its anterior surface.

Tscherning maintains that the ciliary muscle in contracting increases the tension of the zonula, and thus induces bulging of the lens anteriorly towards the centre, and hardly at all towards the periphery.

It must be distinctly borne in mind that an emmetrope uses no accommodation to focus parallel rays. Rays coming from an object situated 6 metres or more away are considered for practical purposes to be parallel, and when an eye is in a state of rest with its accommodation completely relaxed, it is said to be adapted for its *punctum remotum* (p.r.), this being the farthest point of distinct vision. Conversely, when the accommodative power is employed to produce its greatest effect, the eye is then adapted for its near point, or *punctum proximum* (p.p.). The p.p. varies therefore with the amount of accommodation which the eye possesses, and can be practically determined by noting the nearest point at which the patient can read the smallest reading type, ·5 Snellen, or can see plainly the wires of the optometer (fig. 13).

The *range of accommodation* is the amount of accommodation necessary to enable an eye adapted for its punctum remotum to readjust itself for its punctum proximum, and in distance is equal to p.r. – p.p.

The *amplitude of accommodation* in an eye is the utmost accommodative power which that eye possesses.

In Em and My. it is equivalent to the range of accommodation. In H., as it is necessary for the eye to first accommodate in order to focus parallel rays (the amount necessary being the measure of the hypermetropia), this must be added to the range which has already been discovered, and the total—viz., the range, added to the amount of the H. in dioptres—represents the amplitude of accommodation.

As the lens increases in size during life, and loses a certain amount of its elasticity, the p.p. tends to recede farther from the eye. In Em. at 10 years old the p.p. is at 7 cm.; at 40 it has receded to 22 cm.; at 50 to 40·5 cm.; and at 75 the accommodative power is entirely suspended, the P.r. and P.p. coinciding.

The amplitude of accommodation in Em. is obtained at any age by dividing 100 cm. by the distance of the p.p. in centimetres (see Presbyopia).

The association of accommodation and convergence.—Besides single or monocular accommodation, it is necessary to consider the binocular range of accommodation, which is intimately connected with binocular vision and therefore with convergence.

The act of accommodation is associated normally with convergence of the two eyes and also with contraction of the pupils. The estimation of convergence power by the metre angle has already been given (p. 334), and the estimation of the amount of accommodation in dioptres necessary for distinct vision at any distance is obtained in a similar manner to the amplitude—viz. by dividing 100 cm. by the distance in cm. at which the object is situated. It is found in normal vision that the number of metre angles of convergence is equivalent to the number of dioptres of accommodation necessary in each eye to see the object distinctly.

Thus for distinct vision at 25 cm., 4 D. of accommodation ($\frac{100}{25}$) are required, and for accommodation at 12·5 cm., or half the former distance, double the amount of accommodation—viz. 8 dioptres—is required, and so on.

We have already found that the amount of normal convergence for 25 cm. equals 4 m.*a.* and for 12·5 cm. is 8 m.*a.*; it is thus seen that the accommodation and convergence are intimately associated and should vary equally, and that we have a method of comparison between these two acts. Thus, an Emmetrope of 10 years of age with

p.p. at 7 cm. should have 14 D. of accommodation for that distance and 14 m.*a*. of convergence. In the same way at 40 years of age with a p.p. at 22 cm. he will have 4·5 D. of accommodation and should have 4·5 m.*a*. of convergence.

Estimation of refraction.—There are three principal methods by which this can be done, and in many cases it is advisable, to avoid error in diagnosis, that all should be employed.

1. By the testing of the distant and near vision of each eye, and the correction of such vision by glasses. This is the least reliable method by itself.
2. By retinoscopy.
3. By the direct ophthalmoscopic method.

1. The estimation of the static refraction by means of vision testing.

Requisites.—Test-types for distant and for near vision and astigmatic fan (these are provided at end of book).

Space sufficient to allow the distant type to be placed at 6 metres from the patient.

Spectacle-frame, and box of lenses (spherical and cylindrical), a measure preferably arranged on the metric system (for description of these see appendix).

The patient is placed at 6 metres in front of the distant type, which must be hung in a good light and at about the level of his eyes.

Each eye is tested separately, whilst the eye not under examination must be either closed or shielded by a card or obturator disc in the spectacle-frame.

The number of the smallest line of the distance type which is read is noted, and then, although not absolutely necessary, valuable information may be gained by giving the patient the near reading type, and measuring the distance at which of his own accord he reads the small type, and also the shortest distance at which he still can read it (p.p.) and the greatest.

A weak convex glass (+ ·5) is placed in front of the eye, and this must be done even if patient's distant vision is $\frac{6}{6}$; we thus obtain two classes of cases:

A. Those in which distant vision is not made worse by a convex glass.

B. Those in which distant vision is made worse by a convex glass.

A. **Distant vision not made worse** (remains the same or is improved) by a weak convex glass proves the patient to be hypermetropic.

The glass must now be increased in strength and a note made of the highest glass with which the best vision is obtained. This is a measure of the manifest hypermetropia (H.m.), which is rarely the whole amount of the H. present. The absolute hypermetropia (H.a.) can be discovered by paralysing the ciliary muscle with atropine or homatropine and cocaine.

Example : V. R.E. $= \frac{6}{6}$; H.m. 1 D. $= \frac{6}{6}$.

V. atropine R.E. $= \frac{6}{12}$; H.a. 2·5 D. $= \frac{6}{6}$.

In this case the H.m. = 1 D, and the H.a. = 2·5 D

If the distant vision cannot be brought up to $\frac{6}{6}$ with convex spheres, compound hypermetropic astigmatism is probably present. This may be demonstrated by means of the astigmatic fan, when it will be found that all the lines are not seen distinctly.

A + ·25 cylinder is now placed in front of the highest convex lens, which does not diminish the acuity of vision, and the cylinder is rotated till the axis is found.

The strength of the cylinder must now be increased till the best vision is obtained, and the cylinder then will be a measure of the astigmatism present, and with the

convex sphere already found will represent the manifest compound hypermetropic astigmatism.

Example: V. R.E. $\frac{6}{18}$ + 1·5 D. = $\frac{6}{9}$ partly, and

$$+ 1{\cdot}5\,\text{D.} \bigcirc + {\cdot}75\,\text{D. Cyl.} \updownarrow = \frac{6}{6}.$$

B. **Distant vision made worse** with a + ·5 D. sphere.

The patient is either emmetropic or ametropic.

These cases may be divided into two classes: (1) In which the vision without glasses is $\frac{6}{6}$, almost all these cases are emmetropic, except occasionally young subjects in whom there is spasm of accommodation, causing the whole of the H. to be latent (in these cases it is rare to obtain a vision of $\frac{6}{6}$); (2) in which the vision without glasses is less than $\frac{6}{6}$.

These cases are either (*a*) myopic or (*b*) astigmatic, and the diagnosis may be made by holding the fan at a distance at which the patient can see it, and finding out from this whether any of the lines are seen less distinctly than the rest. If the lines are seen equally well the patient is myopic.

a. Myopia.—Concave glasses are now placed in front of the eye, commencing with the low ones, – ·5 D. or – 1 D., and gradually increasing till the best vision is obtained.[1] It is important to remember that the *lowest* glass giving the best vision is the measure of the My. For distant vision, a rough approximation of the amount of My. may be obtained by the letters read. Thus a myope with V. = $\frac{6}{12}$ has about – 1 D., with $\frac{6}{24}$ – 2 D., and with

[1] In the high degrees of myopia—viz. more than 6 D.—the corrected vision rarely amounts to $\frac{6}{6}$.

$\frac{6}{36}$ – 3·5 D. These numbers must be borne in mind, as if the glass procuring $\frac{6}{6}$ is manifestly too high, there is probably spasm of accommodation. *Example.* V. $= \frac{6}{9} - 3$ D. $\frac{6}{6}$, whereas if the case were simple My. of 3 D., the correction would be V. $= \frac{6}{36} - 3$ D. $\frac{6}{6}$.

Myopes should always see the smallest reading print ·5 at a certain distance, and a very useful method of estimating My. of medium and high degrees is by measuring the greatest distance in centimetres at which the patient can see the ·5 type.

The amount of My. is obtained by dividing 100 by this distance (P.r.) Thus if the patient sees ·5 at 25 cm. the My. $= \frac{100}{25} = 4$ D.

My. can be more correctly gauged by vision testing than any other form of ametropia.

(*b*) *Astigmatism* (As.).—The accurate estimation of As. by vision-testing, unless retinoscopy or the ophthalmoscope has been previously employed, is almost impossible; from this fact it is mere waste of time to try to diagnose the different forms of As. by vision-testing, and the descriptions hereafter are confined to testing for the different forms of astigmatism when the diagnosis has been already made.

Simple myopic astigmatism.—Begin with – ·5 D Cyl. and rotate it till the axis is in the position the patient sees best; increase the strength of the cylinder till $\frac{6}{6}$ or the best vision is obtained. The weakest glass producing this is the measure of the astigmatism.

Ex.: V. $= \frac{6}{12} - 1$ D. cyl. $\longleftrightarrow = \frac{6}{6}$.

Simple hypermetropic astigmatism is estimated in a

similar way to myopic astigmatism, except that convex cylinders are used, and that the highest glass with which the best vision is obtained is the measure of the astigmatism.

Ex.: $V. = \frac{6}{9} + \cdot 75$ D. Cyl. $\updownarrow = \frac{6}{6}.$

Compound myopic astigmatism.—Begin with the concave sphere, correcting the lowest meridian which has been found by retinoscopy, add a weak concave cylinder (·5 D.), and rotate it till the axis is found, increase the strength of the cylinder till best vision is produced. If vision is not improved to $\frac{6}{6}$ make changes in the sphere, but in the high degrees vision is seldom improved to $\frac{6}{6}$.

Ex.: $V. = \frac{6}{60} - 3$ D. Sph. $= \frac{6}{12}$, and

$- 3$ D. Sph. $\bigcirc - 1 \cdot 5$ D. Cyl. $\longleftrightarrow = \frac{6}{6}$,

and in another case

$V. = \frac{3}{60} - 8$ D. Sph. $= \frac{6}{18}$, and

$- 8$ D. Sph. $\bigcirc - 2$ D. Cyl. $\longleftrightarrow = \frac{6}{12}.$

Mixed astigmatism.—Correct the myopic meridian as nearly as possible with a – Sph. then place + Cyl. of a strength equal to the difference between the meridians found by retinoscopy, and with its axis in the myopic meridian, rotate slightly till the best position is obtained, and note the angle marked on spectacle-frame, increase or decrease this cylinder, and, if vision is still less than $\frac{6}{6}$, make changes in the sphere.

Estimation of dynamic refraction (*accommodation*).—This is equivalent to estimating the amplitude of accommodation, for which see p. 368.

Retinoscopy (keratoscopy, skiascopy, shadow test) is the method of determining and estimating the refraction by observing the changes in intensity and direction of movement of the shadows, which are produced at the edges of the red reflex, seen on illuminating the eye by a concave or plane mirror.

When light is thrown into the eye, a small amount of the fundus is illuminated, the rest being in shadow; therefore, if light is thrown by the mirror of the ophthalmoscope into the eye, there is seen an illuminated portion (red reflex), but the greater part of it is in shadow. On rotating the mirror the red reflex moves together with the shadow.

The requisites are: A dark room; a lamp placed behind and above the patient's head and so shaded that the light is only thrown towards the observer, the patient's face being in shadow; spectacle-frame, box of lenses, and an ophthalmoscopic mirror.

With regard to the patient: The pupil is preferably dilated, and the accommodation paralysed by a mydriatic. The transparent media should be clear, and there must be no photophobia.

The observer, seated at about 1 metre distance, throws the light from the large concave [1] ophthalmoscopic mirror into the patient's eye, whilst the patient looks steadily in the direction of, and beyond, the mirror. If the observer is ametropic he should either wear his spectacles or else a lens correcting his refraction in the sight-hole of the ophthalmoscope. The red reflex should be seen, and on rotating the mirror slowly so that the light moves

[1] In this description a concave mirror is used, as it is supplied with every ophthalmoscope; but some oculists prefer to estimate with a plane mirror. If the plane mirror be employed, the distance of the observer from the patient should be increased; the shadows will then move in exactly the opposite direction: viz. *with* for H. and E., and *against* for My.

horizontally the red reflex partly disappears, and the manner in which this occurs depends upon the refraction of the eye. If Em. or H., a shadow appears on the side towards which the light is moving, and passes across the pupil; it therefore moves *against* the direction of the light from the mirror. If the light is moved vertically, a similar shadow is seen also to move vertically and in the opposite direction to the light.

If a low convex lens is placed in front of the patient's eye, the movement of the shadow is made quicker, and by increasing the strength of the lens this effect is also increased, till at last the shadow is seen to alter its direction and to move in the same direction as the light. In My., the shadow appears to move in the same direction as the movement of the observer's mirror, and is corrected by placing concave glasses in front of the patient's eye till the movement is seen to be *against*. The lens, which just neutralises the shadow, is spoken of as the correcting lens, and this will be for the distance at which the observer is sitting from the patient—viz. 1 metre; for infinity, therefore, about 1 dioptre must be subtracted from all results, making H. and Em. a little less than the retinoscopy, and My. a little more.

Where high degrees of ametropia are present, the red reflex is usually obscured, and the shadow consequently difficult to make out; the best method to adopt in these cases is to put up a + 6 D. and then − 6 D.; with one of these lenses the red reflex will be made still more indistinct; with the other the ametropia will be more or less corrected, and the shadow seen without difficulty; from this point the retinoscopy can easily be completed.

To save time, in an ordinary case, after the shadow is seen at the commencement of the examination, a moderately high lens of about 3 dioptres is put up, and the retinoscopy continued according to whether this under or over corrects the movement of the shadow.

In all these cases each meridian is corrected separately, but it will often be found that one meridian requires a higher lens to correct its shadow than the other; in these cases As. is present.

The most usual positions for the two meridians in As. are vertical and horizontal. These are determined by the edge of the shadow, the horizontal meridian having a vertical edge, and *vice versâ*.

But in cases of astigmatism it is frequently found that the edges of the shadows are placed more or less obliquely, but still at right angles to each other. In correcting these meridians the light must also be moved in an oblique direction and parallel with the movement of the shadow.

3. **The direct ophthalmoscope method** of estimating refraction since the introduction of retinoscopy has been much neglected. This is a fact to be deplored, as the student does not now examine the disc and yellow spot region as carefully as he used to. In cases of H. this method can be rendered very accurate, even to half a dioptre, but in cases of myopia, the result is generally not so correct.

Requisites.—Refraction ophthalmoscope, and a lamp that can be placed beside the patient, as described in Chapter II. p. 20, 'Direct Close Ophthalmoscopic Examination.'

The observer should look at a blood-vessel between the disc and macula, and then move the wheel of the ophthalmoscope so that the + glasses are rotated in front of his eye. If the vessel becomes obscure by + ·5 D. or + 1 D., the patient is not H.; but if it is seen as well, or better, the higher lenses + 2 D. &c. are used till the vessel becomes a little blurred. It saves time to pass the lenses rather quickly, and to make the vessel appear obscured as soon as possible, and then to rotate the wheel in the opposite direction till the vessel is seen clearly again. The highest glass with which the vessel can be seen distinctly is the measure of the H.

My. is estimated in a similar way, but the lowest glass with which a vessel can be seen distinctly is the measure of the refraction.

Astigmatism can be measured by taking vessels which run in different directions, preferably vertical and horizontal, and correcting them.

In estimating the refraction by the direct close method, the observer must be able to keep his accommodation completely relaxed, and if he be ametropic he can either place a lens, completely correcting his error of refraction, behind the sight-hole of the ophthalmoscope in the disc (fig 5, I), or else he must allow for his own error by subtracting or adding it to the result obtained. This can be done by considering the lens representing the observer's refraction as zero in the chain of lenses, and counting from it. Thus if the observer's refraction is +3, and in a case the details are best seen by him with + 7 D., as + 3 is

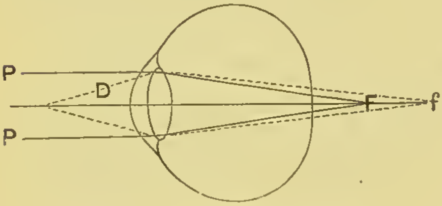


FIG. 101.—HYPERMETROPIA

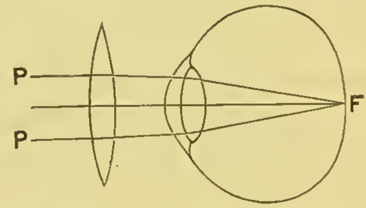


FIG. 102.—HYPERMETROPIA CORRECTED BY CONVEX LENS

zero, the patient must have + 4 D. of H.; and if in another case −5 is the lowest concave glass with which details are seen distinctly, as +3 is zero, the patient must be myopic to the extent of 8 D.

ERRORS OF REFRACTION.—**Hypermetropia** (ὑπέρ, above; μέτρον, measure; ὤψ, eye). *Definition.*—An eye is hypermetropic (fig. 101) when with the accommodation completely relaxed, parallel rays (P) are brought to a focus (F) behind the retina and divergent rays (D) still further back (*f*).

This eye at rest is adapted for convergent rays (fig. 97c), and as such rays are only found after passing through

certain refractive media, it follows that a hypermetropic eye cannot form a distinct image of any object, far or near, without either increasing the convexity of the lens by the act of accommodation, or placing a convex lens (fig. 102) in front of the eye of such a strength that the rays are made sufficiently convergent.

It will thus be seen that the hypermetropic eye, unless provided with a convex glass equal to its H., is continually accommodating both for far and near objects. The effect of this condition is that the ciliary muscle is more or less in a state of spasm, and from this spasm being difficult to overcome and relax, the amount of H. present can as a rule only be found by the aid of atropine. Hypermetropia is divided into absolute H. (H.a.), the amount found when the ciliary muscle is not acting, and manifest H. (H.m.), that found by vision testing without complete relaxation of the ciliary muscle.

The difference between these amounts is called the latent H. (H.l.). Thus:

$$V. = \frac{6}{9}\ \text{H.m. } 1{\cdot}5\ \text{D.} = \frac{6}{6};\ \text{atropine } \frac{6}{18}\text{H.a. } 2{\cdot}5\ \text{D. } \frac{6}{6}.$$

In this case the manifest H. is 1·5 D., the absolute H. 2·5 D., and the latent H. 1 D.

H. usually dates from birth, and most children are hypermetropic at birth, though they may afterwards become less hypermetropic, emmetropic or myopic. Most mammals, except man, are hypermetropic.

H. is usually described as due to a want of development of the eye. In most cases there is a shortening of the antero-posterior diameter, and this variety is known as *axial* H., which, though generally congenital, may be produced by detachment or tumours pushing the retina forwards. It may also be caused by changes in the media, as flattening of the cornea following cicatrices produced by wounds or inflammation; lowered refractive index of the lens in old people about 70 (*acquired H.*); dislocation or removal (aphakia) of the lens.

The symptoms, when present, are those of *asthenopia* (ἀσθενής, weak; ὤψ, eye) due to excessive accommodation, and are therefore more marked after close work, as reading, sewing, especially by means of artificial light. They consist of flushing of the conjunctival vessels, slight photophobia, blinking, deep-seated pain referred to the back of the eyes and lachrymation; near objects as print appear distinct one moment and blurred the next. Headache, generally frontal though sometimes vertical or occipital, neuralgia and migraine are frequently complained of, especially when the patient is out of health.

These symptoms, due to the accommodative strain, may scarcely be felt when the patient is young and enjoying good health with plenty of out-door exercise, but occur when he follows sedentary occupations, and are frequently met with when a boy leaves school for the university or an office. They are also found after debilitating illness, pregnancy or lactation, and are then attributed to the loss of tone in the ciliary muscle setting free latent hypermetropia.

Signs.—Objective. The eyes appear more deeply set than usual, and farther apart; the sclerotic in front is flatter and the anterior chamber shallow. There may be an apparent external strabismus.

In high and moderate degrees of H. there is a flattening and want of relief in the face especially noticeable about the root of the nose, forehead and orbital borders; in the low degrees these signs are not as a rule observable.

Vision testing.—Distant vision is generally good $\left(\frac{6}{6} \text{ or } \frac{6}{9}\right)$ in H. of less amount than 3 D., and in young adults may be so up to 5 D., but in adults over 20 the acuity of vision is usually reduced.

The vision of an eye under atropine is sensibly reduced, and though a patient may see $\frac{6}{6}$ without glasses this probably becomes $\frac{6}{18}$ under atropine.

Near vision.—The P.p. in H. is for the same age farther away than it is in Em.

Ophthalmoscope, direct distant.—The retinal vessels and the disc, when seen, appear to move in the same direction as the observer's head, the image being erect.

Retinoscopy.—With the concave mirror held at about 1 metre distant, the shadow moves distinctly *against*, and can be corrected by the addition of convex lenses placed in front of the patient's eye. The lens which just corrects the shadow, if a slight deduction be made for the distance the observer is sitting at, is the measure of the H.

Direct close (see footnote, p. 15).—Details of the fundus can be seen distinctly with convex glasses behind the mirror. The highest convex glass which can be used will indicate the amount of the H. present within a small margin of error, depending mostly on the observer's skill. The retinal vessels near the disc frequently appear dilated and tortuous; a crescent may be present, and, especially in the young, the retina has an appearance like watered or shot silk.

Indirect method.—On withdrawing the objective lens any details of the fundus seen decrease in size.

Complications.—Hypermetropes are predisposed to many forms of chronic inflammation of the lids, lashes, and conjunctiva; among these may be mentioned ciliary blepharitis and phlyctenular conjunctivitis. Glaucoma is more frequently met with in hypermetropic eyes than in any others, and spasm of accommodation is found in young adults. The most important complication is convergent concomitant strabismus (p. 348).

Pathology.—The hypermetropic being a small eye there is less room for the ciliary muscle, and in consequence the ciliary body is placed further forward, with the result that in the arrangement of the muscle the anterior or circular fibres appear more numerous; in addition to this, owing to the increased necessity for accommodation,

there is a tendency for the ciliary muscle to become hypertrophied.

The *diagnosis* should be made by retinoscopy, or by the direct close ophthalmoscopic method, although in adults H. may be fairly accurately found by vision testing, without paralysing the accommodation. Any patient who can see as well or better at a distance with a + glass must necessarily be hypermetropic, and the highest glass with which he can see perfectly indicates the amount of the H. which is *manifest*. It must be remembered that H. may be present although no manifest H. can be found.

Vision testing with atropine. The highest + glass which the patient can tolerate for distant vision indicates the absolute H. If the manifest H. be deducted, the latent H. or that which was obscured by spasm of the ciliary muscle, is shown.

Prognosis.—In children, when H. is due to a shortened visual axis, there is a tendency for the ametropia to diminish as the eye increases owing to the growth of the child. The percentage of hypermetropes among children is far greater than among adults.

H. in adult life as a rule remains stationary, but in some cases in young adults the H. rapidly diminishes and myopia sets in; this is really a form of progressive myopia beginning in a hypermetrope. After the age of 50, a slight increase may commence and slowly progress till the age of 80, when the increase amounts to about 2 D. This is due to a change in the refractive index of the lens.

Treatment.—In young children under four years of age where H. has been found, care must be taken that the child does not use his eyes more than is absolutely necessary for near objects till proper correcting glasses can be used with safety; this will usually be at about four or five years, according to the disposition of the child. The glasses must be decided upon after examination under atropine by the direct ophthalmoscopic method or retinoscopy. If the

child has already a convergent squint it is all the more important that accommodation and convergence should be used as little as possible till the ametropia is corrected.

In young adults with small amount of H., if the patient has perfect vision with both eyes at all distances and neither asthenopia nor squint, it is unnecessary to order glasses. In slight cases of H. (less than 2 D.) with asthenopia, &c., the total H. may be corrected and the glasses only used for reading and near work. In higher degrees, especially if the patient has not previously worn glasses, great care must be taken not to fully correct the error, as, if a sudden change be made, the relation existing heretofore between accommodation and convergence is no longer maintained. The whole of the manifest H. may be corrected and the glasses always worn ; after a few months, if much latent H. be present, the strength of the glasses may be increased.

In patients of 35 and upwards there is seldom any latent H. In these cases, it is best to correct all or nearly all the absolute H. The correcting glasses should be worn always for near work and constantly if asthenopic symptoms continue. Where the amplitude of accommodation is less than + 3 D. from whatever cause—viz. old age, weakness, &c.—two pairs of spectacles will be necessary, one pair, correcting all or nearly all the absolute H., to be worn for distance, and the other of a greater strength, for reading and near work.

In hypermetropes with convergent concomitant strabismus, the correcting glasses must be worn constantly, and if in a young patient the squinting eye is amblyopic, an attempt should be made to improve the vision by covering up the glass in front of the good eye for an hour or two every day. Under this treatment the squint may entirely disappear ; if it fails, operative procedure must be resorted to, if the vision in the squinting eye after correction by glasses is fairly good.

Aphakia is the condition of the eye when the lens, from removal or dislocation, no longer fills the pupillary aperture.

The effect on the static refraction of the eye is to reduce it to the extent of about 10–12 dioptres; consequently unless the patient was very myopic previously he now becomes extremely hypermetropic. It is worthy of note that in cases of excessive myopia the reduction in the static refraction is usually much greater than 12 D. and may amount to as much as 20 D. Consequently aphakia and myopia are rarely associated. The dynamic refraction is of course entirely abolished.

The signs by which this condition may be diagnosed are the following: the presence of only the corneal reflex on focal illumination, the images normally seen on the anterior and posterior surfaces of the lens being absent; a deep anterior chamber with the anterior plane of the iris flattened or even concave; a tremulous iris upon movement of the eye; and the complete absence of any power of accommodation.

It is thus seen that the patient, if both eyes are aphakic, is clinically in a similar condition to that of a hypermetrope of the age of 75, and will require at least two pairs of spectacles.

Treatment.—If both eyes are in a condition of aphakia, as a rule most patients manage fairly well with full correction for distance glasses and an increased strength of + 3·5 or + 4 D. for reading glasses, though, if expense is no object, an intermediate strength for the middle distance is also very useful. To save the necessity of constantly changing the glasses two strengths are often combined in each side of the spectacle-frame (bi-focal or Franklin glasses).

If one eye only is aphakic, binocular vision is impossible, and therefore a glass should only be given if the vision corrected is better than that of the other eye.

Myopia (μύω, I close; ὦψ, eye) is present in an eye (fig. 103) when, with the accommodation completely relaxed, parallel rays (P) are brought to a focus (F) in front of the retina, and certain divergent rays (D) depending on the amount of the My. are focussed (*f*) on the retina.

It must be clearly understood that only divergent rays (fig. 97), coming from a distance dependent on the amount of My., are brought to a focus on the retina, as rays from points farther away are focussed in front of, and those nearer to the eye, behind the retina.

From this it follows that the myopic eye (fig. 103) could only receive parallel rays if it were possible for the lens to become less convex by relaxing accommodation or by employing a concave lens which would make parallel rays sufficiently divergent (fig. 104).

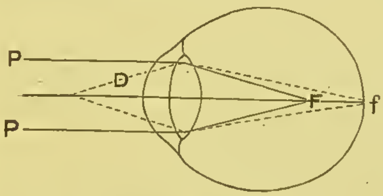


Fig. 103.—Myopia

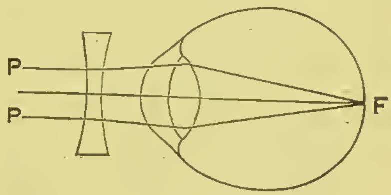


Fig. 104.—Myopia corrected by Concave Lens

In My. the P.r. is at a distance less than infinity, and this, the greatest distance at which the smallest print can be distinctly seen, is the measure of the myopia; thus, if it is seen at ·5 metre, the My. = 2 D., and if at ·25 metres, My. = 4 D.

The P.p. depends on the amplitude of accommodation, and theoretically, with an equal effort of accommodation, the P.p. is nearer than in Em. or H.

In My. the range of Acc. is equivalent to the amplitude.

My., in contradistinction to H., is rarely present at birth, and commences as a rule from about 8 to 10 years of age, when a child is beginning to use his eyes more for near objects, as lesson-books.

My. may have its origin in (1) elongation of the optic axis (axial My.), or (2) changes in the refraction of the lens (refractive My.).

(1) *Axial myopia.*—This is generally produced by enlargement of the whole eye during the period of active development (8 till 18 years), or rarely, before birth. It may also result from a limited protrusion of the sclerotic (posterior staphyloma), or occasionally from too great convexity of the cornea (conical cornea).

(2) *Refractive myopia* is usually due to spasm of the ciliary muscle (accommodation spasm), or sometimes to changes in the lens itself, as cataract.

Symptoms are sometimes absent, and in slight degrees patients may have no idea that their distant vision is not up to the average. The most common complaint is blurred distant vision, with sometimes pain on either side of the nose after reading (convergent asthenopia). In progressive My., deep-seated pain in the eyes is usually present, and one or more of the various complications which are usually associated with these cases.

Thus high myopes see badly at night; complain at times of sparks, circles, and flashes of light; straight lines may appear broken or bent; photophobia may be very troublesome; dark patches may be seen before the eye, and these relative scotomata may become absolute; there may be mental hallucinations, as seeing faces, &c.

The *signs* are elongation of the head in the antero-posterior diameter (dolichocephalic), a long face, large prominent eyes with dilated pupils, and deep anterior chambers; a peculiar peering mode of screwing up the eyes and making the palpebral apertures into chinks; any near work, as print or sewing, is held very close to the eyes. Patients generally have a stooping gait, are round-shouldered and tend to acquire a contracted chest.

In high My. binocular vision is very rarely met with, owing to the ellipsoidal shape of the eyeball, and its interference with convergence movements.

Vision testing.—Distant vision is always below the normal, and is lower in proportion as the My. is higher. Vision of near objects is good, and the patient, if allowed to choose his own distance, ought to be able to see Sn. ·5. Under atropine the distant vision is not greatly reduced. In estimating refraction in young people without atropine, the liability of the apparent My. being due to spasm of accommodation must always be taken into account.

The reduction of distant vision varies according to the amount of the My. thus, a patient with -1 D. sees about $\frac{6}{12}$ or more, -2 D. $\frac{6}{18}$, -3 D. $\frac{6}{36}$, -4 D. $\frac{6}{60}$ or less.

These figures are important to bear in mind, as beside real My. cases occur in children and young adults of apparent My. resulting from spasm of the ciliary muscle. In these cases, the distant vision is not reduced in a degree corresponding to the glass necessary to give $V.=\frac{6}{6}$. This spasm may induce a My. of 4 to 5 D., and disappears under atropine (see p. 409).

Ophthalmoscope, direct distant.—A small inverted image of the fundus can usually be seen, and will appear to move in the opposite direction to the observer's head.

Retinoscopy.—With the concave mirror held at a distance of 1 metre, the shadow is seen to move distinctly with, and is corrected by the addition of concave lenses put in front of the patient's eye ; the lowest lens, which overcorrects and makes the shadow move against the direction of rotation of the observer's mirror, is about 1 D. less than the amount of the My.

In high degrees, the shadow is very faint, but becomes

darker and moves more quickly on putting up concave lenses.

Direct close (see footnote, p. 15).—Details of the fundus cannot be seen distinctly until a concave lens is placed behind the mirror, and the lowest concave glass with which the details are seen clearly will indicate the amount of My.

A crescentic whitish patch is often seen on the outer side of the disc, due to thinning of the choroid, and is called a myopic crescent (Plate IV. *b*.).

Indirect.—On withdrawing the lens slightly, the details seen will appear to increase in size.

Two clinical varieties may be described—namely, *simple* (which does not tend to increase much) and *progressive* (resulting generally in high My.). It is very difficult to draw a hard-and-fast line in this classification, as all cases, except the rare congenital forms, commence as simple myopia and increase either slowly or quickly.

The *course* varies greatly both as to rate of increase and length of time during which that increase continues. In an ordinary case of *simple* My., the increase is very slight, perhaps 1 D. a year for two or three years, and then the progress ceases. In the *progressive* form, it increases at a greater rate and for a longer time, and in extreme cases the increase may be as much as 5 D. in six months (*malignant My.*). In all forms of My. there is seldom any increase after the age of 25. In high My. the amount reached may be as much as 25 D.

In low degrees under 3 D. the only *complication* as a rule is the atrophic change in the choroid near the disc called a myopic crescent, which is generally limited, and less than one-fifth of the diameter of the disc in width. The crescent may be greyish or white, the edges sharply cut or irregular, with the retinal vessels passing across it.

From 3 D. to 6 D. the crescent is usually more marked, and if at any time the My. has been stationary there may

be two concentric crescents, the more recent one being on the outer side of the first. As a rule there are no symptoms of asthenopia. From 6 D. upwards the My. may be called *high*; the vision is seldom $\frac{6}{6}$ when corrected with glasses, the crescent is nearly always present, and its width is greater and may even exceed the diameter of the disc. A posterior staphyloma or limited bulging of the sclerotic may take the place of the crescent.

Insufficiency of convergence, which may give rise to asthenopia (muscular), is commonly present and often leads to external strabismus.

In *malignant My.*, there is generally a well-marked posterior staphyloma, patches of choroidal atrophy exposing the sclerotic, and generally appearing as if punched-out, and having deeply pigmented edges (fig. 41). The optic disc may be hyperæmic and its edges indistinct. Retinal hæmorrhages, especially in the neighbourhood of the yellow spot, and pigmentary changes in the same region, radiating streaks in the retina as if due to traction, and detachments of the retina occasionally occur; vitreous opacities are often present, and occasionally lenticular striæ. Owing to these retinal and choroidal complications the vision may be reduced even to only perception of light.

In most cases of axial My. *predisposing causes* may be found. Amongst these heredity and race are probably the most important; but the increased percentage of myopes in town dwellers makes environment another factor, probably because distant vision is not so necessary or so much used as by dwellers in the country. The Hebrew and German races are especially subject to My.

Determining causes.—The age of the patient from 8 to 16. During this time the most active growth of the eye takes place, and it corresponds to the period of school life, with long hours of work at short distances.

Many children acquire a habit of holding print close

to the eyes, and exert in consequence exaggerated convergence power, which, from pressure of the internal recti tends to elongate the eyeball. Other factors associated with work at a short distance are faulty position of the body, the patient leaning over his work and so inducing congestion of the head and interference with the circulation; insufficient and bad illumination, and the use of print the letters of which are badly formed, being too close together or too small; loss of health, especially when associated with anæmia, in those already somewhat predisposed to My.

Axial myopia is very seldom found at birth, is rare before the age of 7 or 8, and most commonly begins to appear about 10. This is probably due to the fact that from 12 to 18 the eye acquires its final form, and at this period there is usually associated a large amount of near work.

A tendency to myopia is produced by prolonged reading and near work; this is shown by the preponderance of myopes over hypermetropes found among studious races, where the near vision is more used than the distant, whereas among savage races, where acuity of distant vision is a vital factor, myopia is almost unknown.

The *diagnosis* in most cases can be made by taking the distant vision, which is usually much reduced, and then obtaining a near vision of ·5 Sn. at some distance. It can be diagnosed from spasm of accommodation by the diminution of distant acuity of vision not corresponding to the glass correcting the error of vision, and also by the apparent myopia, due to spasm, disappearing on atropinisation of the eye.

The amount of My. found in a case by glasses without atropine being used is frequently too high; in the same way My. estimated under atropine is generally about 1 D. too low.

The crescent, though generally present, is not diagnostic, as it is found in H. or As.

Malignant My. can only be diagnosed by the history of the symptoms and by examinations of the vision at different times.

Prognosis.—In low and moderate degrees of My. there is no tendency after the age of 25 to any increase. In simple My. without complications, there should be no increase in most cases if proper correcting glasses are worn.

In malignant Myopia with retinal and choroidal complications, the prognosis is grave, as even if the disease is arrested with useful vision, the patient must for some years use his eyes as little as possible for close work, and this must necessarily interfere with the pursuit of all sedentary occupations.

My. by the laity is generally called strong sight, and this probably arises from the fact that myopes can read without glasses after 45, when even emmetropes have to take to spectacles for close work. A myope of 1 to 3 D. has certainly, with the exception of imperfect distant vision, a distinct advantage in not needing to use his ciliary muscle so much, which enables him to read much longer at a time without symptoms of asthenopia. Myopes are less liable to glaucoma or complete cataract than other forms of ametropia.

The *treatment* of My. is directed to the maintenance of binocular vision, together with the prevention in young adults of the further progress of the disease.

The improvement of distant vision, which is often all the patient asks for, is of minor importance.

Preventive treatment.—The following rules should be adopted with all young myopes in order to check any tendency to increase in the My., and most of them should as far as possible be carried out in schools, so as to prevent the chance of the children becoming myopic from bad hygienic conditions.

The child should sit up at a desk in such a way that he cannot bend over his work. This is best effected by the combination of a desk and seat with a support for

the back, and so arranged, that when the child has sat down the desk can be pulled over his knees.

The desk should have a sloping top, and the height must be so arranged that when the child is sitting the distance from the eye to the book is about 14 inches (35 cm.). The child should be instructed that the head is never to be brought down to the work, but the work brought up to the head.

The illumination must be steady and not too strong or too dim ; if the child is right-handed the light should come from the left side and from behind.

The type of the school books should be well printed, large, clear, and with good spacing.

The child should not as a rule be allowed to read too long at a time ; young myopes are especially prone to be studious.

The health should also be attended to, and proper hygienic principles adopted in the class-rooms.

Glasses should be worn for near work to prevent strain from excessive convergence.

Myopic children should never be placed too far from the blackboard at school.

All myopes under 20 should be instructed to hold their books at about 32 cm. from their eyes, and to avoid reading or working by bad illumination, as twilight or firelight ; this latter they are very prone to do, as a myope sees much better by feeble illumination than an emmetrope. A good plan, when the eyes are tired, is to splash or open them under cold water.

Slight amount of myopia gives rise to little inconvenience, and under 3 D. patients go about without needing glasses, except to see distant objects for a lengthened time, as the play or a picture gallery. In these cases, the constant use of glasses diminishes the acuity of distant vision when glasses are not worn ; this is certainly a reason for not wearing glasses for distance except when

a lasting and continuous effort is necessary. I am sure that the most reasonable treatment of ordinary myopia is to try and prevent too great convergence by wearing glasses for near work, and to encourage the patient to use his unaided eyes for distance. With children this is a most difficult matter, as when once the general sight is improved by glasses they will not leave them off except on compulsion.

In children with My. of 1 D. with good accommodation the treatment should be to watch carefully and to combat any tendency or habit to hold books too close, in which cases spectacles — ·75 D. should be used for reading, so as to prevent convergence strain, but in many cases no glasses need be used.

If the My. is 2 D. glasses may be used for reading of —1D. strength; up to 5 D. spectacles of about two-thirds of the My. may be ordered and should be used for reading, meals, &c. I am quite aware that many oculists order glasses equal to the full amount of the My. in all cases up to 5 D. to be worn constantly, but my objections to this are, that the wearing of glasses is a distinct detriment to the appearance of the child, that it is not absolutely necessary to the treatment, and that the distant vision without glasses becomes sensibly reduced. (I have known many cases in which the vision has been reduced from $\frac{6}{18}$ to $\frac{6}{60}$ without any increase in the My.)

In adults when the My. is over 5 D. glasses correcting about two-thirds or less of the My. may be ordered for reading if there are symptoms of strain, and another pair, equal to the full correction when using the eyes for a lengthened period at distant objects; the reading glasses should be of sufficient strength to enable the patient to read at not less than 32 cm. (12 inches). The most important point in the treatment of My. is that too strong glasses should never be ordered.

In high My. over 14 D. in adults, the question of glasses must depend on the symptoms; in many cases it is best that the patient should do as much as possible without glasses, owing to the fact that such eyes are very unsound. In such cases, if symptoms of retinal or choroidal irritation set in, the use of correcting glasses must be discontinued; the patient should wear peacock-green domed spectacles or neutral-tinted goggles, cease all work, and be kept at rest in a darkened room, avoiding any excitement and living abstemiously without alcohol. Any strain, such as constipation, must be guarded against by treatment; mercury in small doses is frequently beneficial, and also strychnine; leeches or blisters may be applied to the temporal region.

Operative treatment.—In children and young adults with high uncomplicated My., the breaking up and removal of the lens by discission, followed generally by linear extraction, is frequently very successful. The advantages gained by removal of the lens are the great improvement in distant vision without glasses, the much lighter glasses worn and the better field given by them. I have done the operation several times, and have as yet experienced no bad results. As a rule, two discission operations are necessary, the first being a slight and limited one, and the second a much freer needling; after leaving the broken-up lens if possible for a month, linear extraction should be done, as much soft matter as possible being evacuated. The result of the operation is that the patient has fair distant vision $\frac{6}{18}$ to $\frac{6}{12}$, improved by low convex glasses, and needs convex glasses for reading.

Example.—Boy, aged 14, with 20 D. of My. and V. $= \frac{1}{60}$; ·5 at 6 cm.; -20 D. $= \frac{6}{36}$; after operation on both eyes the V. of each eye $= \frac{6}{18} + 1{\cdot}5$ D. $\frac{6}{9}$: $+ 3$ D.

Sn. ·5 at 24 cm., and he has binocular vision for distance and near.

Astigmatism (α, not; στίγμα, point) is the condition present when there is not the same curvature in all the meridians of one or more of the refractive surfaces. The refraction errors before described have been for spherical surfaces, in which rays coming from a luminous point are brought to a single focus at a certain distance behind the refractive surfaces. In astigmatism, owing to the surfaces not being spherical, rays coming from a luminous point are brought to a focus, not at a single point but at different points corresponding to the curvatures of the refractive surfaces. The two chief foci in these cases are those corresponding to the greatest and least curvatures, and the distance between these foci is a measure of the astigmatism present.

Astigmatism may be divided into (1) *irregular*, in which there is a difference of refraction in parts of the same meridian owing to changes in the cornea or lens; and (2) *regular*, where the refraction in a meridian is the same throughout, but there is a difference in two meridians (*chief meridians*) at right angles to one another and called those of maximum and minimum refraction; regular As. is usually corneal (*static astigmatism*).

1. *Irregular astigmatism* is generally due to changes in the cornea, such as conical cornea, or as a result of cicatricial contractions following corneal wounds or inflammations. It may also be produced by partial dislocation of the lens or changes in the refractive indices of different sectors of the lens.

By the ophthalmoscope any details that can be seen of the fundus appear to be greatly distorted.

Acuity of vision for distant and near objects is much diminished, and, save for the use of convex glasses for reading (magnification), can seldom be improved to any great extent.

The slight amount always present, even in normal eyes, is the reason for the fixed stars being seen not as round points of light but as radiating lines. Monocular polyopia may result from the irregular As. present occasionally in the sectors of the lens.

2. *Regular astigmatism.*—Every eye has a certain amount of regular As., from the fact that the cornea is not a segment of a true sphere, but has the greatest curvature in the vertical meridian and the least in the horizontal. An astigmatic cornea may be likened to a piece taken out of the side of an egg. It can be demonstrated by taking two fine lines at right angles to each other, one vertical and the other horizontal, when it will be found that the horizontal is seen distinctly much closer than the vertical and appears nearer to the eye than the vertical, whilst the latter is more distinct farther away. The reason for this is that the horizontal line is best appreciated by the vertical meridian.

In looking at a vertical line with an astigmatic eye, if the rays passing through the vertical meridian are out of focus, and those passing through the horizontal meridian in focus, the object will be slightly elongated, and the sides seen distinctly, because each point of light will be seen as a small vertical line, and consequently will overlap and be lost upon the surface of the object looked at. But if the rays passing through the vertical meridian are in focus and the horizontal ones out of focus, the apparent length of the vertical line will not be increased but the width will be increased, because in this case each point of light will be seen as a small horizontal line, and consequently the line will appear blurred. From this it will be understood that in looking at narrow objects, such as lines, in order to see them distinctly it is of greater importance that the rays passing through the meridian at right angles to the long axis of the object should be in focus than *vice versâ*, and hence in testing for astigmatism with thin

parallel lines the As. is necessarily present in the meridian at right angles to the lines which are seen most indistinctly.

Regular astigmatism may be divided into the following varieties, according to the refraction of the chief meridians :—(1) *Simple,* in which one meridian is Em. and the other H. or My., comprising therefore simple H. As. and simple My. As. (2) *Compound,* in which the chief meridians are either unequally H. (compound H. As.), or unequally My. (compound My. As.). (3) *Mixed,* in which one meridian is H. and the other My.

In most of these cases the cornea has, as in the normal eye, the greatest curvature at or near the vertical meridian, and the least in the horizontal ; and therefore the vertical meridian will have a tendency to My. and the horizontal to H. This is a great help in most cases in determining the direction of axis of the cylindrical glass required. In simple As. the vertical meridian will be Em. in H. As., and My. in My. As. ; in compound As. the vertical meridian will be less than the horizontal in H. As., and greater in My. As. ; and in mixed As. the vertical will be My. and the horizontal H.

Symptoms are the same as in other forms of ametropia, but are usually more marked. The acuity of vision is reduced for all distances. The asthenopia (accommodative) is especially noticeable during near work, and the headache and neuralgia, which are frequently complained of, are more or less chronic, and are always aggravated by any attempt to read for a lengthened period.

The amount of As. necessary to produce these symptoms depends partly on the variety present—the hypermetropic, both simple and compound, invariably causing more asthenopia than the myopic variety—and partly on the disposition of the patient, very small amounts, as little as ·5 D., being sufficient to cause marked asthenopic symptoms, especially in young adults reading for examinations.

Simple H. As. and My. As. of low degrees are both very common, and often give rise to no symptoms till long-continued strain is put upon the near vision, when asthenopia will be brought out. In the higher degrees, asthenopia and indistinct vision are usually present.

Compound H. As. resembles H. of equal degree, but the symptoms are more aggravated. In extreme cases, vision is always much reduced at all distances, and as the patient has never seen an absolutely distinct object of anything, perfect vision must not be expected after correction till the glasses have been worn for some time.

Compound My. As. A certain amount of astigmatism is frequently present in cases of high myopia, and seldom causes more symptoms than My. of equal degree.

Mixed astigmatism. Vision at all distances is very imperfect and there is marked asthenopia.

There are no definite *signs* of As., but the patient frequently has a vacant look and is in the habit of screwing up his eyes; children with As. are often thought to be stupid, dull and heavy, especially at school work.

Vision testing.—Distant vision, except in very slight cases, is always below the normal, and cannot be brought up to $\frac{6}{6}$ with spherical lenses. The presence of As. may be demonstrated by holding up the astigmatic fan in front of the patient, when it will be found that some lines are seen much more distinctly than others. If the As. is compound or mixed the acuity of distant vision when corrected by glasses is in many cases below the normal as $\frac{6}{18}$ or $\frac{6}{12}$, but it generally improves after the glasses have been worn some time.

If a stenopaic (στενός, narrow; ὀπή, hole) slit about 1 mm. in diameter be placed in front of the eye and rotated, the distant vision in one position of the slit is much

improved, corresponding to a chief meridian; convex spheres may now be placed in front of the slit, and if vision is made worse concave spheres must be used; the highest convex or lowest concave with which most improvement is obtained is a measure of the refraction in this meridian. The slit is now rotated to right angles with the former position, and the same procedure adopted, and the refraction in this meridian also obtained.

The slit is now removed and a spherical glass of the same strength as the lesser H. or My. meridian placed in the frame, and the difference corrected by means of a cylinder placed with its axis at right angles to the greater meridian.

It is better not to spend too much time in attempting to estimate astigmatism by vision testing, as the only reliable method is retinoscopy under atropine.

Ophthalmoscope; Retinoscopy.—The direction of movement of the shadows must be first made out, and then each of the chief meridians is corrected separately by placing spherical glasses in front of the eye, and a note then made of the strength of the lens which just over or under corrects the meridian. This is usually represented by two cross lines

$$\begin{array}{c} + > +6\,\text{D.} \\ > +3\,\text{D.} \end{array}$$

corresponding to the direction of movement of the shadows, and the refraction found is written opposite them. In the example given above, the mark > (greater than) before a number means that the meridian corresponding to it is less than the next higher number. Ex., > 3 D. means less than 4 D.

Direct close.—Except in cases of H. As. this method is not very reliable. It is usual to start by taking a horizontal vessel between the optic disc and yellow spot, and finding the highest convex or lowest concave lens with which it can be distinctly seen. In the same way a

vertical vessel is estimated, and after deducting from ·5 D. to 1 D. in H., and adding ·75 D. in My., the amount and variety of the astigmatism present is found.

Course.—Static astigmatism when present is permanent, as even if the eye changes in its refraction the difference in the two chief corneal meridians will remain the same, and on the other hand an increase in the astigmatism is equally unlikely. The complications which may be expected are those which accompany H. in hypermetropic cases, and of My. in myopic cases. In My. As. a crescent is often met with.

In cases of convergent concomitant strabismus associated with H., the presence of As. in one eye only may often determine the fixing of the squint in that eye.

Causation.—Regular astigmatism is in almost every case congenital, and there is generally a history of heredity. It may, however, be *acquired*, and then results from cicatrisation or changes in the cornea from inflammation, or more frequently from operation wounds, as cataract extraction and iridectomy. Occasionally it is induced by partial dislocation of the lens.

Diagnosis.—The possibility of the presence of astigmatism is always to be considered when, the media being clear, perfect distant vision is not obtained by the use of spherical lenses.

With the astigmatic fan or clock, certain lines will be seen distinctly whilst others are blurred, and the position in which the lines are most clearly seen corresponds with the astigmatic meridian.

Distant vision is improved by employing a stenopaic slit 1 mm. in diameter, and rotating it till it corresponds with the meridian of least error.

With the *ophthalmoscope* the disc, instead of appearing circular, is elongated in one meridian. And with the *direct close* method this apparent elongation corresponds with the meridian of greatest refraction, and is at right angles to the direction in which the elongation is

seen with the indirect method. On looking at a vessel it will be noticed that its curves of the vessel are not accurately focussed at the same time.

Treatment.—This is by means of glasses, and the rule is that if worn at all in As., they should be worn always. Naturally the correction of such a defect gives the patient quite a different estimation of all objects, and his symptoms would not be relieved by the correction being only for a certain distance. In some cases, where As. has existed for years, the correction cannot be tolerated, and in many, only perseverance on the part of the patient enables cylindrical glasses to be worn. In most, however, the proper glasses act almost magically by relieving the asthenopic symptoms.

In As. in young children, who cannot read, the correction must be made under atropine, and the axis chosen according to the general rule (page 397).

Simple As.—Low degrees, either My. or H., in young persons should be fully corrected, and the glasses worn at first for reading and near work; if symptoms are not relieved, glasses must be worn constantly.

Example.—Case aged 10. Retinoscopy under atropine:

$$\begin{array}{l} \quad + > +3\text{ D.} \\ > + \cdot 5\text{ D.} \end{array}$$

which, subtracting + ·1 D. all round for the distance of observer, gives

$$\begin{array}{l} + > +2\text{ D.} \\ \text{Em.} \end{array}$$

A cylinder, + 1·5 D., is now placed in front of the patient's eye and rotated until the axis is found, and

$$\text{V} = \frac{6}{24} + 1\cdot 5\text{ D. Cyl.} \updownarrow = \frac{6}{6}.$$

The glass ordered is + 1·5 D. Cyl. $\updownarrow$.

Case aged 19. Retinoscopy under atropine:

$$\begin{array}{l} + \text{Em.} \\ > -3\text{ D.} \end{array} \text{ and } V = \frac{6}{24} - 3\text{ D. Cyl.} \longleftrightarrow = \frac{6}{6},$$

and glass ordered -3 D. Cyl. $\longleftrightarrow$.

Compound As.—In My. As. care must be taken not to order too strong glasses; the rules laid down under My. must be observed. The whole of the As. may be corrected in all cases, the alteration, if any, being made in the sphere according to the rules under H. and My.

Example.—Case aged 18. Retinoscopy under atropine:

$$\begin{array}{l} + > -2\text{ D.} \\ > -4\text{ D.} \end{array}$$

The As. is arrived at by subtracting the meridians $= -2$ D., and in order to obtain the retinoscopy result a spherical glass, -2 D., and a cylinder, -2 D., would be required. In practice such glasses are put in front of the eye, and by rotating the cylinder the axis is found, which in this case would probably be horizontal. As under atropine the amount of My. found is less than the amount present, these glasses may, as a rule, be ordered. The case above works out as

$$V = \frac{6}{36} - 2\text{ D.} \supset -2\text{ D. Cyl.} \longleftrightarrow = \frac{6}{6}.$$

Example.—Case aged 20. Retinoscopy under atropine:

$$\begin{array}{l} + > +4\text{ D.} \\ > +2\text{ D.} \end{array}$$

Here the difference in the meridians is $+2$ D., which is the As., and the result would be $+2$ D. sph. and $+2$ D. Cyl. On placing these glasses before the eye the axis of the cylinder is first found, and is probably vertical, as below:

$$V = \frac{6}{36} : +1\text{ D.} \supset +1{\cdot}5\text{ D. Cyl.} \updownarrow \frac{6}{9}.$$

Mixed As.—This is much the most difficult kind to treat successfully; in choice of glasses, a concave cylinder should be preferred to a convex, and placed next the eye, forming the posterior surface of the glass.

Example.—Case aged 15. Retinoscopy under atropine:

$$\begin{array}{l} + > +3\text{ D.} \\ > -2\text{ D.} \end{array}$$

Here the difference between the meridians is obtained by adding the numbers corresponding to them, and the result therefore will be the strength of the cylinder. Thus in this case 2 D. + 3 D. = 5 D., and 5 D. is the cylinder; and the cylinder to be taken may be either + 5 D. or − 5 D. The two formulæ giving the result of above retinoscopy are: $+3\text{ D.} \bigcirc -5\text{ D. Cyl.} \longleftrightarrow$ or $-2\text{ D.} \bigcirc +5\text{ D. Cyl.} \updownarrow$ As mentioned above, it is more satisfactory to take the concave cylinder, and the

$$V = < \frac{6}{60} + 2\text{ D.} \bigcirc - 5\text{ D. Cyl.} \longleftrightarrow \frac{6}{12}:$$

and this glass may be ordered.

Anisometropia (ἄνισος, unequal; μέτρον, measure; ὤψ, eye), or unequal refraction of the two eyes, is present in most people to a small extent, and is especially noticeable in astigmatism. The term is only used, as a rule, for those cases in which the difference is great enough to make it necessary for unequal glasses to be used.

Varieties.—(1) One eye may be emmetropic and the other ametropic. (2) Both eyes may have the same variety of ametropia, but unequal in degree. (3) One eye may be myopic and the other hypermetropic.

The *diagnosis* is as a rule easy, and the only difficulty arises in prescribing glasses. In cases of the *first* group, without asthenopia or squint, and with good vision in the ametropic eye after correction, it is not as a rule advis-

able to prescribe glasses. Some patients, if the ametropic eye is myopic, like to wear an eyeglass for distance.

In the *second* group the difference between the two eyes should be allowed for, and unequal glasses ordered.

In the *third* group it is usually found after careful examination that the patient uses the hypermetropic eye for distance and the myopic for reading. If he suffers no discomfort and distant vision is good, there is no necessity for glasses. Under these conditions binocular vision is quite impossible. If the distant vision in the myopic eye is much improved with a concave glass, a single eyeglass may be ordered for that eye.

ERRORS OF ACCOMMODATION.—**Presbyopia** (πρέσβυς, old; ὤψ, eye), or old sight, is said to be present when, from permanent loss of dynamic refraction, the punctum proximum has receded to a greater distance than 22 cm. (about 8½ inches) from the eye. This measurement is quite arbitrary and has been decided upon because it has been found that patients begin to suffer inconvenience after this point has been reached.

From the age of 10 upwards there is a steady and continuous diminution in the amplitude of accommodation, due to a sclerosis or loss of elasticity in the lens, which does not respond to an equal extent to the same muscular effort. At 10 years of age the amplitude of accommodation amounts to about 14 dioptres, and this in an emmetrope would give a punctum proximum at 7 cm. (2¾ inches). The following table gives the rate at which the amplitude diminishes:

Age	Amplitude of accommodation	Punctum proximum in emmetropia
10	14 D.	7 cm. (2¾″)
20	10	10 cm. (4″)
30	7	14 cm. (5½″)
35	5·5	18 cm. (7¼″)
40	4·5	22 cm. (9″)
45	3·5	28 cm. (11½″)

Age	Amplitude of accommodation	Punctum proximum in emmetropia
50	2·5.	40 cm. (16″)
55	1·75	57 cm. (23″)
60	1	1 m. (40″
65	0·75	1·3 m. (52″)
70	0·25	4 m. (160″)
75	0	corresponds with punctum remotum

This table shows that very little accommodation remains after the age of 60, and that all power of accommodation is suspended at the age of 75.

The earliest *symptoms* patients complain of are that they are obliged to hold their reading type, sewing, &c., at a greater distance than they have been accustomed to, and that the print looks pale. In consequence they find that without a bright light they read small print with great difficulty. Besides illuminating the text, the bright light causes contraction of the pupil, and thus improves the definition. If proper correcting glasses are not used, a train of asthenopic symptoms is liable to be set up, such as pain and smarting of the eyes, 'letters running together,' and in some cases a chronic form of conjunctivitis.

In Em. the symptoms become manifest after the age of 40, but in H. they occur much earlier in life, the date varying according to the degree of H., but in any case the symptoms will commence after the range of accommodation is reduced to 4·5 D.; for example, in H. of 1 D., at the age of 35, the amplitude is 5·5 D. and the range of accommodation only 4·5, and consequently, the patient will be presbyopic at this age, and a hypermetrope of 4 D. will be presbyopic at the age of 25.

In My., on the other hand, Pr. is delayed because the P.p. is situated nearer to the eye than in an emmetrope of the same age and amplitude of accommodation. For instance, a myope of 1 D. will not be presbyopic till his

range of accommodation has diminished to 3·5 D., which will occur at the age of 45; and a myope of 4·5 D. can never be presbyopic except from changes in his static refraction.

The *course* is progressive, and consequently the glasses must be increased in strength at least once in every five years. It must not be forgotten that a rapidly increasing presbyopia is often a sign of incipient glaucoma, and is occasionally met with in diabetes and other wasting diseases.

The *diagnosis* has to be made from paresis of accommodation. The acuity of vision must first be taken, the refraction estimated, and the P.p. measured. From these data, the amplitude of accommodation can be worked out, and must be compared with the age of the patient by means of the table (p. 404). If paresis is absent, and the punctum proximum is beyond 22 cm., presbyopia is present.

Treatment.—Patients who have not been accustomed to the use of glasses are sure to find some inconvenience when they first take to them, and, as the most important point is to make the patient comfortable, it is not advisable to insist on the use of glasses in the early stages until the patient himself feels the need of them. In an ordinary case of Pr. without asthenopic symptoms there is no harm in putting off as long as possible glasses for reading, but rather an advantage, as when once the glasses are taken to, it is very difficult to do without them, and an appreciable amount of useful sight without glasses is lost. The first glasses should always be weak, + ·5 D. or + ·75 D., whatever the amount of presbyopia present, and they can be changed for stronger glasses after the weaker ones have been worn for a few months.

The purpose for which the glasses are needed must be carefully inquired into, together with the distance at which the patient wishes to work, as reading, violin playing, painting, sewing, will all demand different distances. A

stronger glass is generally required at night by artificial light than by day, and at first the glass probably need only be worn at night. The P.p. having been measured, the glass necessary will be the difference between a lens of a focal length equal to the required working distance and a lens of a focal length equal to the distance of the P.p.

For example, suppose that patient's P.p. is at 50 cm., and that he wishes to read at 20 cm., then the glass necessary will be the difference between a lens of a focal length of 20 cm., = 5 D., and a lens of a focal length of 50 cm., = 2 D., which will give a lens + 3 D., and this glass should enable him to read at the required distance.

The changes in accommodation are in most cases so uniform that patients can often be fitted up from their age; the rule is to add + 1 D. for every five years after 40 in order to obtain distinct vision at 22 cm.

In most cases, it is advisable to prescribe glasses rather under this calculation, thus + ·75 D. at 45 years, or + 1·5 D. at 50 years, &c. In ametropia the amount of the presbyopia must be added to the refraction error; in H., therefore, the glass ordered is higher than in Em. by the amount of the H.—thus a hypermetrope of 2 D. and aged 50 would need + 3·5 D. (2 D. + 1·5 D.). A myope of 1 D. and same age would need – 1 D. + 1·5D. = + ·5 D., and a myope of 5 D. would never be presbyopic in the ordinary course of events.

Paralysis of accommodation, or cycloplegia (κύκλος, circle; πληγή, stroke), when accompanied by paralysis of the pupillary muscle is called *ophthalmoplegia interna*; it may be partial or complete, and in either case is usually bilateral, except when produced by local application of a mydriatic as atropine or by traumatism. Paresis or partial paralysis of the accommodation without affection of the pupil is generally produced by some debilitating cause, such as excessive lactation, diabetes, diphtheria.

The symptoms are due to the loss of range of the accommodation, and their severity will depend upon the refraction of the patient.

In Em. distant vision is not affected, but near objects appear blurred, and the patient will be unable to read without the aid of convex glasses. In H. the distant vision is reduced, and the near vision is affected to a greater extent. Low degrees of myopia will resemble emmetropia in the symptoms, but in the higher degrees (viz., more than 4 D.), as the far point is situated close to the eye, the patient seldom uses his accommodation, and consequently does not miss the loss of it.

Signs.—The P.p. is found to have much receded, and in cases of complete paralysis coincides with the P.r.

Causation.—It is produced by the use of mydriatics, such as atropine, duboisine, daturine, and cocaine. It is one of the symptoms in complete paralysis of the third nerve. Cycloplegia is not uncommon as a sequela of diphtheria, and usually makes its appearance about three or four weeks after the commencement of the attack—in fact, the throat affection may be so slight that cycloplegia is in some cases the first sign that the patient has had diphtheria. The failure of the accommodation reaches its height in two or three days, and is generally believed to be due to a form of neuritis.

A blow on the eye will frequently interfere with the proper action of the ciliary muscle in the injured eye, causing a more or less complete paralysis; the pupillary muscle is affected at the same time.

Diagnosis.—The amplitude of accommodation must be measured, when it will be found that in cases of paresis the loss of accommodative power is greater than the age of the patient would warrant (see table, p. 404), and in complete paralysis that there is no accommodation and that the P.p. corresponds with the P.r.

The *prognosis* as to recovery is good when due to the

use of mydriatics or to diphtheria, and also in syphilis unless the nucleus of the third nerve is involved.

In traumatism, when the paralysis is complete, unless the ciliary muscle has begun to recover after two or three days the prognosis is not good. It will be noted in such cases that the ciliary muscle begins to recover before the pupillary.

The *treatment* to be adopted must depend upon the cause, but in all cases, except those due to general want of tone, eserine should be used locally.

Constitutionally, if syphilis is the cause it must be treated. In diphtheria, general tonics and hypodermic injections of strychnine are indicated, and in anæmia, iron.

When due to traumatism, the treatment indicated is complete rest for the eye and the local application of cold with eserine drops three times a day. If the paralysis is permanent, a convex lens will be necessary for close work unless the patient is very myopic.

Tonic spasm, or inability to completely relax the ciliary muscle, is a condition frequently met with in young people. It may be found in Em. and in any variety of ametropia, but is most common in H. It can be artificially produced in an eye by the continued use of a powerful miotic, such as eserine or pilocarpine.

Asthenopia and blurred distant vision are the usual symptoms complained of. An emmetrope will appear to be myopic, distant vision will be blurred $\frac{6}{12}$ or $\frac{6}{9}$, improved to $\frac{6}{6}$ with a fairly strong concave glass, -2 D. or -3 D.

In H., spasm of accommodation is synonymous with latent H., and consequently the greater the spasm present the less H.m. and the more H.l. The spasm may be so great that the patient appears to be My.

In myopes with spasm the My. appears to be increased.

In all cases the amplitude of accommodation, which varies with the age of the patient, will be found to be diminished owing to the approximation of the P.r. to the P.p. in Em and My., and in H. to the increase in the latent H. It is nearly always due to long-continued reading or near work.

Diagnosis is made (1) from the history of the recent loss of acuity for distant vision ; (2) by vision testing and estimation of the amplitude of accommodation, when it will be found that the patient appears to be myopic and has a greater loss of accommodative power than his age would warrant; (3) by estimating the refraction under atropine by the direct method or by retinoscopy, when if spasm had been present, the result found will differ widely from the ametropia estimated without atropine. In young patients with small amount of apparent myopia the possibility of the presence of spasm must always be considered.

Treatment.—In Em. as little reading as possible, and the use of weak convex glasses for all near work until the spasm has passed off.

In H. weak atropine drops should be used for a few days, and the patient fitted up with proper glasses.

In My. no special treatment is required, apart from that indicated by the My. itself. Care must always be taken in these cases not to over-correct the error of refraction.

CHAPTER XXIII

EYE SYMPTOMS AND DISEASES IN GENERAL DISEASES

In the following pages, as far as possible, the ocular symptoms and diseases found associated with the chief general diseases are mentioned.

Infective fevers.—Very frequently, associated with high temperature, hyperæmia of the conjunctiva is met with.

Measles is often accompanied by ciliary blepharitis, catarrhal conjunctivitis, phlyctenules, and corneal ulcers.

Scarlet fever is occasionally attended by severe mucopurulent conjunctivitis.

In **smallpox**, some days after the eruption, ulceration of the cornea ensues, attended sometimes by perforation and followed by corneal nebulæ, leukoma adherens, or even destruction of the eye. The pustules never occur on the cornea, though they have been seen on the conjunctiva.

Vaccinia may produce, by inoculation, an ulcer on the conjunctiva or lid.

In **mumps**, there may be enlargement and inflammation of the lachrymal gland.

In **pyæmia**, septic embolism may occur in the retinal or choroidal vessels, followed by purulent uveitis (panophthalmitis).

In **septicæmia**, retinal hæmorrhages are found, and their presence indicates grave mischief.

Chronic or **subacute rheumatism** may have as complications episcleritis, scleritis, iritis, and extra-ocular paralyses.

Gout.—The most common symptom is the so-called *hot eye*, in which the patient complains of grittiness, congestion, and feeling of heat, often accompanied by small concretions in the palpebral conjunctiva. Episcleritis, scleritis, and iritis are frequently met with, and sometimes corneal ulcers. Glaucoma occurs in gouty subjects, and another complication is hæmorrhagic retinitis.

Influenza.—Numerous ocular symptoms have been attributed to this disease, which have probably only been due to the general weakness occasioned by it.

In **purpura** and **scurvy** retinal hæmorrhages are found.

Erysipelas of the face may spread to the orbital cavity, giving rise to orbital cellulitis, and in some cases blindness results from atrophy of the optic nerve, or the eye may be destroyed from necrosis of the cornea following the proptosis.

In **myxœdema** the lids are swollen, and amblyopia has been recorded.

Anæmia.—Retinal hæmorrhages, retinitis, papillitis, retro-ocular neuritis, and paralysis of an extrinsic ocular muscle, as the external rectus, may occur.

Leucocythæmia.—Retinitis.

Diabetes.—Retinitis, hæmorrhages in the retina or vitreous, loss of accommodation, central scotoma, and iritis. Cataract, which is symmetrical, rapidly progressing, and of the soft variety; in a few cases it has been known to disappear, the lens becoming clear. Extraction is generally successful if the patient is not passing a great excess of sugar in the urine, and the question of operation should always be decided on this condition, as diabetic coma has been known to ensue a few hours after the operation.

Graves' (Basedow's) **disease**, or exophthalmic goître. The eye symptoms are numerous, and some or all of them are generally present.

The most frequent is prominence of the eyeballs (exophthalmos), which is as a rule slow in progress, though cases have been known of its occurrence in a marked degree in one night from shock. It may affect one eye only, but is generally bilateral. The lids frequently do not cover the cornea during sleep, and in extreme cases the eyeballs may become dislocated through the palpebral aperture. The eyeballs are not enlarged, and as a rule recede after death. The exophthalmos is probably due to overfilling of the blood-vessels in the retro-ocular fatty connective tissue. The normal involuntary lid wink is very much diminished in frequency and may even be absent.

The upper lid does not follow the downward movement of the eyeball, but halts suddenly (Von Graefe's symptom). The palpebral aperture is enlarged, exhibiting a greater amount of the sclerotic than is normally seen. As a result of the exposure of the cornea, ulceration may occur, generally in the lower half, and this may be followed by xerosis of the cornea, iritis, and general destruction of the eyeball.[1]

These cases are mostly found in females, but when present in males the symptoms are much more severe.

Treatment is mainly constitutional. In cases where the proptosis is extreme, or ulceration has commenced, the operation of tarsoraphy may be performed, either by uniting the whole palpebral aperture for a time, or only the median portion.

Diphtheria.—The ocular symptoms, except conjunctivitis, occur after the acute stage of the disease, and are therefore more properly called post-diphtheritic. They consist of paresis or paralysis of accommodation, weak-

[1] *Trans. Opth. Soc.* vol. xvi. p. 187.

ness of convergence power with diplopia for near objects, anæmia of the retina, concentric contraction of the fields of vision (fig. 48), and occasionally paralysis of an extrinsic ocular muscle. From direct contagion, membranous conjunctivitis may result.

Syphilis.—*Acquired.* A *primary* sore may be found on the eyelid or conjunctiva.

Secondary.—Iritis may be an early symptom dating from six weeks to three months after appearance of the primary lesion, and cyclitis may accompany it.

The later symptoms are gumma of the iris, choroiditis, retinitis, irido-cyclitis, and, very rarely, interstitial keratitis.

Tertiary symptoms are rupial sores about the lids, gumma of the sclerotic, periosteal nodes of the orbital bones and optic atrophy. Owing to disease of the nervous system, there may be paralysis of the extra-ocular and intra-ocular muscles.

Hereditary.—The most common manifestation is interstitial keratitis; iritis, disseminated choroiditis, and optic atrophy may also occur.

Gonorrhœa.—In rheumatic patients, iritis and scleritis may be found. The purulent conjunctivitis associated with this disease is due to direct infection.

Tubercle.—The ocular manifestations are frequently very difficult of proof. In the last stages of acute miliary tuberculosis, small multiple deposits have been seen and found in the choroid. Large solitary masses, generally about the yellow spot, have been diagnosed as tubercular. Iritis, cyclitis, keratitis, and scleral bosses are found in tubercular patients; and I have seen one case of tubercle of the lachrymal gland.

Circulation.—*Heart disease.*—Pulsation of the retinal arteries is seen in aortic insufficiency; retinal hæmorrhages are frequently met with in the last stages of valvular disease.

Fatty heart.—Hæmorrhages into the vitreous and retina.

Arterial disease (atheroma).—In aneurysm of the aorta, dilatation of the pupil and palpebral aperture from irritation of the sympathetic are found, or miosis, slight ptosis and sinking of the eye in the orbit from paralysis of the same. Other signs are hæmorrhages into the vitreous and retina, also thrombosis and embolism of the retinal vessels.

Severe hæmorrhage is sometimes followed by amblyopia without any ophthalmoscopic signs, except a pale disc and small retinal vessels; afterwards optic atrophy may ensue. In other cases papillitis, retinal hæmorrhages and white plaques may be present.

Respiration.—From severe paroxysms of coughing, as in whooping-cough, subconjunctival hæmorrhages are often found, or even detachment of the retina.

Nasal disease.—Owing to the communication through the lachrymal passages of the conjunctival sac with the nose, disease may spread from the one to the other.

In acute and chronic coryza and hay fever, conjunctival congestion and mucopurulent conjunctivitis are frequently met with.

In chronic rhinitis, inflammation about the inferior meatus may obstruct the nasal duct, and produce lachrymal abscess.

Ear disease.—Owing to disease of the external auditory meatus or the middle ear, nystagmus may occur.

Digestion. *Teeth.*—Numerous symptoms have been reported as accompanying toothache and diseases of the teeth. Amongst these may be mentioned iritis, keratitis, cyclitis, glaucoma, and paralysis or spasm of accommodation.

Constipation.—Subconjunctival, vitreous, or retinal

hæmorrhages result from the straining attending this condition.

Urinary. *Nephritis.*—The lids are often œdematous, but the most important symptom is albuminuric retinitis, found chiefly in chronic interstitial nephritis; it may be accompanied by papillitis, or detachment of the retina. The retinitis in such cases is an extremely grave symptom, as patients often die within one year of its appearance, and rarely live more than two years.

Gravidic retinitis resembles the ordinary albuminuric type, but its import is not so grave.

In cases where uræmia is impending, blindness sometimes occurs (uræmic amaurosis) without any ophthalmoscopic appearances; this condition is due to poisoning of the cerebral centres, and may be preceded by hemiopia.

Sexual organs.—In women, disorders of the menstrual function give rise to cyclitis, vitreous and retinal hæmorrhages, papillitis, and retro-ocular neuritis.

Pregnancy.—Gravidic retinitis occasionally occurs, and may necessitate induction of premature labour; it is liable to return during subsequent labours.

Lactation is frequently accompanied by paresis or paralysis of accommodation, and over-lactation from its debilitating influence may produce corneal ulcers.

Nervous system. Brain.—*Cerebral hæmorrhage* may be attended by various ocular symptoms according to the part of the brain affected.

Tumour of the brain is generally associated with papillitis, which is as a rule binocular; if it commences in one eye before the other, the tumour is probably on the same side as the eye first affected.

Abscess of the brain may be accompanied by papillitis, but not so frequently as tumour.

Meningitis may cause papillitis, especially if basal and of tubercular origin.

Disseminated sclerosis.—Nystagmus is the most

frequent ocular symptom; central scotoma, contraction of the field of vision, and diplopia also occur, but as a rule the pupillary reflexes are normal.

Herpes ophthalmicus [1] is characterised by vesicles following the distribution of the ophthalmic division of the fifth nerve. The eruption may be limited to one or more of the branches of this nerve, the frontal being the most often implicated. The ocular complications of this disease are corneal ulceration, iritis, cyclitis, scleritis, vitreous opacities, and panophthalmitis. They may be met with in any case, but most frequently when the nasal division is affected, owing to the fact that this nerve supplies the interior of the eyeball and the cornea with sensory nerves. Like herpes zoster in other parts of the body, there is severe neuralgia along the distribution of the nerve before the vesicles appear, and this may last for many months after their appearance, being often attended by the sensation of formication.

The scarring of the vesicles is frequently very marked.

Treatment.—Most cases have a gouty history, and should be treated constitutionally. Locally, the vesicles must be protected from the air, and a good plan is to paint them with collodion.

For the neuralgia and formication after the vesicles have disappeared, I have found a mixture of chloroform and eau de Cologne painted along the cutaneous distribution of the nerves give greatest relief.

Spinal cord.—*Locomotor ataxia* is the most common spinal disease with ocular symptoms. Primary atrophy of the optic nerve occurs, and is marked by its slow progress; both eyes are generally affected, though not necessarily at the same time.

The pupils are often unequal and not regular; in the later stages there is usually miosis. They frequently

[1] *Trans. Ophth. Soc.* vol. vi. p. 390.

react to accommodation, but not to light (Argyll Robertson or spinal pupils), and in some cases react to neither.

Friedreich's disease.—Nystagmus is generally present, but diplopia and spinal pupils are rarely met with.

Sympathetic nerves.—In irritation of the cervical sympathetic, the pupil is dilated on the same side, the palpebral aperture enlarged, and the eyeball a little prominent.

In paralysis or destruction of the cervical sympathetic, the pupil is slightly contracted, the palpebral aperture diminished with the appearance of ptosis, and the eyeball sunk in the orbit (enophthalmos).

General and functional nervous diseases. *Hysteria.*—The vision is often greatly diminished, with normal reaction of the pupil to light, and absence of ophthalmoscopic changes. There is concentric diminution of the fields of vision, which sometimes present a spiral shape (fig. 48); the colour fields may be abnormal as to their arrangement. Diplopia may be present, and retinal, corneal, or palpebral anæsthesia. Spasm of the extrinsic muscles, and more rarely paralysis, are occasionally met with.

Epilepsy.—There may be a visual aura. During the tonic stage, the retinal arteries are constricted, and there may be spasm of the extrinsic ocular muscles, conjugate deviation of the eyes, nystagmus, and hippus. Errors of refraction, especially astigmatism, are among the exciting causes, and the fits have been much diminished in number and severity by proper glasses.

Migraine.[1]—The attacks are accompanied by fortification spectra, scintillating scotoma, and hemianopsia; its subjects are often astigmatic and hypermetropic.

Headache, including neuralgia, when constantly recurring, is frequently associated with, and mainly dependent on a refraction error, or in rarer cases,

[1] Gowers, *Trans. Ophth. Soc.* vol. xv. p. 20.

weakness of convergence power or of accommodation. In children, the association is very common, and every child suffering much from headache should have the refraction estimated under atropine.

These ocular headaches are especially met with when the patient is debilitated, or has altered his mode of life. If the ciliary muscles, as well as the other musculature of the body, have a healthy tone, errors of refraction may be scarcely felt; but when, as in the case of a schoolboy going into an office or even to the university, a more sedentary life is led, headaches often ensue.

The most common refraction errors producing headaches are hypermetropic astigmatism, hypermetropia, myopic and mixed astigmatism, and the frequency is in the order named. Simple myopia without an error in convergence power is probably never an exciting cause.

The convergence errors associated with headaches are mainly those of insufficiency; the accommodation causes are presbyopia, paresis or paralysis of the ciliary muscle, and spasm of the same muscle.

The position of the headache or neuralgia varies very much; the most common site is the brow and frontal region, but in many cases the pain, and often tenderness, is referred to the occipital, temporal, parietal, and vertical areas. The neuralgic pain is generally bilateral, but may be unilateral, especially in cases of anisometropia.

Treatment.—The refraction, accommodation, and convergence power should be carefully tested in every case of recurring headache, and any error should be most accurately estimated. In cases of astigmatism even ·25 D. should be corrected by glasses; the lenses to be ordered must be prescribed according to the directions laid down under the several headings in the chapter on 'Refraction.' I have had cases under my care in which headache and

[1] *Practitioner*, 1888, pp. 274 and 279; 1895, p. 33.

even migraine have been cured by simply decentring a + 1 D. pair of spectacles, and others in which the correction of an error as small as − ·5 D. of myopic astigmatism has effected a cure.

Drugs, &c. which may give rise to ocular disease.

Atropine.—The long-continued application of atropine to the eyes induces conjunctival congestion, and an eczematous condition of the lids and the surrounding skin. It may also cause weakness of the ciliary and pupillary muscles and even glaucoma.

Lead.—In chronic lead poisoning there may be retro-ocular neuritis.

The use of lead lotions in ulcers of the cornea is attended by a white deposit on the ulcerated surface.

Quinine given in large doses, as in malarial fever, has resulted in temporary total loss of sight. The visual field is exceedingly contracted, the optic disc pale, and the arteries small and thread-like; the symptoms being apparently due to spasm of the arteries.

Tobacco used in any form may cause retro-ocular neuritis.

Bisulphide of carbon[1] vapour, if inhaled for a considerable time, produces retro-ocular neuritis, and is met with in persons employed in indiarubber works.

Alcohol has been credited with the production of retro-ocular neuritis, but I have never seen a case in which tobacco was not being used at the same time.

[1] *Trans. Ophth. Soc.* vol. v. pp. 149–175.

APPENDIX

FORMULÆ

Collyria (Guttæ), or lotions, are generally made with distilled water, but rose or cherry laurel water is sometimes used. They keep badly, especially cocaine, but this may be to a certain extent overcome by the addition of a few grains of boracic acid. They are generally used by means of a dropper, or narrow tube with a piece of indiarubber at one end. The drops should be placed in the eye by pulling down the lower lid and allowing them to fall on the palpebral conjunctiva. The patient should be told to close his eyes for a few seconds after the application. All collyria used for operations should be freshly prepared with sterilised distilled water.

Lamellæ are made with gelatin and some glycerin, and are the most useful form of employing the mydriatics and miotics. They are very easily applied by a probe or camel's-hair brush to the palpebral conjunctiva of the lower lid and, owing to the gelatine basis, they are not so diffusible as drops, an important point in using a drug like atropine.

Ointments for the eye may have for their basis soft paraffin (vaseline), which keeps well, and does not as a rule irritate the eyes or change when exposed to the air. It should be without taste or odour, and the white is better than the yellow. If vaseline does not suit the eyes, lanolin or unguentum cetacei may be substituted. The alkaloidal eye ointments (B.P.) are now made with oleic acid, and the other B.P. ointments are made up with Unguentum Paraffini, a mixture of hard and soft paraffin.

Fomentations are made with boiling water.

Method of using.—Pieces of absorbent cotton-wool should be soaked in the nearly boiling mixture, wrung out, and applied

to the lids of the closed eye as hot as the patient can bear. After this has been repeated several times for about ten minutes, a piece of the soaked cotton-wool should be applied to the eye, covered with gutta-percha tissue to prevent evaporation and quick cooling, and bandaged on.

Mydriatics

The mydriatics are drugs which dilate the pupil, and at the same time the ciliary muscle. It must be remembered in ordering any mydriatic, that a dilated pupil may induce glaucoma in an eye so predisposed. It is therefore important that a strong mydriatic like atropine should not be used for persons over 40 years of age if a weaker one, as homatropine or cocaine, can be employed.

Atropine group. Atropine (Belladonna). *Action.*—It produces a widely dilated pupil, which does not act to any of the reflexes. It also paralyses and dilates the ciliary muscle, giving rise to paresis or paralysis of accommodation. The action is greater and more lasting on the pupillary muscle than on the ciliary, owing to the former being smaller. A drop of atropine (4 gr. to the oz.) dilates the normal pupil in thirty minutes, but takes at least forty-five minutes to paralyse the ciliary muscle. After atropinisation, the ciliary muscle does not completely recover itself for four days or more, whilst the pupil may be still dilated seven days afterwards. This sustained effect is important to remember in ordering drops for refraction purposes, as the patient must be warned of the length of time during which he will be incapacitated from his work or study.

Abnormal action.—Atropine may give rise to local irritation, shown by an eczematous condition of the eyelids, or to a general poisoning. To avoid the latter, care must be taken, if a solution of the drug is used, to press over the puncta for half a minute after the instillation so as to prevent absorption by the lachrymal passages.

Toxic effects.—Children are more liable to these than adults; they become very drowsy, and suffer from a dry mouth, sore throat, and headache. There may be a red punctate rash resembling that of scarlet fever, muttering delirium, rapid pulse, but no rise of temperature. Acute mania for a few hours may occasionally occur.

Uses.—For its *dilating* action on the pupil.—In cases of iritis (to arrest formation, and to break down, if formed, posterior synechiæ), cyclitis, central ulcer of the cornea. After operations, as iridectomy, cataract extraction, or central wounds of the cornea with prolapse of iris.

For its local *sedative* action and power of keeping the ciliary and pupillary muscles at rest.—In cases where its mydriatic properties are needed, and also in superficial corneal mischief, retinal and choroidal disease, &c.

For *optical* purposes, by enlarging the pupil in cases of lamellar and incipient nuclear cataract.

In *refraction* cases, to paralyse the accommodation; and in cases of spasm of accommodation, to overcome such spasm.

1. Collyrium atropinæ sulphatis

Atropinæ sulphatis	gr. ij
Aquæ destillatæ	℥j

The drops may be used stronger, 4 gr. to the oz., or much weaker, $\frac{1}{2}$ to $\frac{1}{10}$ gr., if desired.

1*a*. Collyrium atropinæ cum cocainâ

Atropinæ sulphatis	gr. ij
Cocainæ hydrochloridi	gr. v
Aquæ destillatæ	℥j

2. Unguent. atropinæ

Atropinæ (alkaloid)	gr. i–ij
Acidi oleici	gr. xl
Adipis	℥j

The B.P. ointment is 10 gr. to the oz., and much too strong for ophthalmic purposes.

2*a*. Unguentum atropinæ cum cocainâ

Atropinæ (alkaloid)	gr. i–ij
Cocainæ	gr. v
Acidi oleici	gr. xl
Adipis	℥j

2*b*. Unguentum atropinæ cum iodoformo

Atropinæ	gr. ij
Iodoformi	gr. lx
Acidi oleici	gr. xl
Adipis	℥j

3. Lamellæ atropinæ

These are made of different strengths, $\frac{1}{5000}$ gr. (B.P.); $\frac{1}{500}$; and $\frac{1}{200}$.

4. Fomentum belladonnæ

Extracti belladonnæ	ʒj ad ʒi
Aquæ destillatæ	Oj

Homatropine. *Action.*—This is similar to atropine, but much weaker, and the effect on the pupillary and ciliary muscles passes off more quickly. The pupil is well dilated in from twenty to forty minutes.

5. Collyrium homatropinæ

Homatropinæ hydrobromidi . .	gr. ij
Aquæ destillatæ	℥j

5*a*. Collyrium homatropinæ cum cocainâ

Homatropinæ hydrobromidi . .	gr. ij
Cocainæ hydrochloridi . . .	gr. v
Aquæ destillatæ	℥j

Drops of this strength are made up with castor oil instead of water and are much used for refraction purposes, as the oily menstruum is not washed away by the tears. The objection to it is that the oil blurs the view of the details of the fundus; it is also very difficult to keep aseptic, and is irritating to many eyes.

6. Lamellæ homatropinæ $\frac{1}{5000}$ $\frac{1}{100}$ (B.P.) or $\frac{1}{50}$

Daturine is used, as is also scopolamine, when atropine is contra-indicated by its having produced symptoms of irritation or poisoning.

7. Collyrium daturinæ

Daturinæ sulphatis	gr. ij
Aquæ destillatæ	℥j

8. Collyrium Scopolaminæ

Scopolaminæ hydrobromidi . .	gr. ij
Aquæ destillatæ	℥j

Other mydriatics of this group are duboisine, hyoscine, and hyoscyamine.

Cocaine group. Cocaine. *Action.*—Its anæsthetic properties are described on p. 436. It produces a widely dilated pupil, which still responds to the contraction reflexes. In combination with atropine or homatropine it gives an ad-maximum dilatation of the pupil, and from this fact the combination is employed in iritis. Cocaine mydriasis is always overcome by eserine, and the combination of eserine and cocaine is useful in cases of cataract extraction without iridectomy, in order to minimise the risk of prolapse of the iris after the operation.

10. Collyrium cocainæ

Cocainæ hydrochloridi . . .	gr. v ad gr. xvj
Aquæ destillatæ	℥j

11. Lamellæ cocainæ gr. $\frac{1}{200}$ (B.P. $\frac{1}{50}$) and $\frac{1}{40}$.

12. Unguentum cocainæ

Cocainæ	gr. x
Acidi oleici	gr. xl
Adipis	℥j

The B.P. ointment is 20 grains to the ounce.

Miotics

These drugs constrict the pupil and the ciliary muscle by stimulating the muscular fibre. They are antagonistic in their action to the mydriatics.

Physostigmine (*eserine*) *Action.*—It produces a very contracted (pin-point) pupil, and at the same time spasm of the ciliary muscle.

Uses.—In peripheral deep corneal ulcer, to remove the iris from the neighbourhood of the ulcer.

In glaucoma it is much used, and acts by drawing the iris from the iridic angle, and so relieving tension.

13. Collyrium physostigminæ

Physostigminæ sulphatis . . .	gr. ij
Aquæ destillatæ	℥j

14. Lamellæ physostigminæ

These are made of sulphate of physostigmine in strength $\frac{1}{1000}$ (B.P.) and $\frac{1}{250}$.

The salicylate of physostigmine may be used instead of the sulphate, and is a more stable salt. Solutions of physostigmine keep badly, and turn a pink colour.

Pilocarpine has the same action as physostigmine, but is not nearly so strong.

15. Collyrium pilocarpinæ

Pilocarpinæ nitratis	gr. ij
Aquæ destillatæ	℥j

16. Lamellæ pilocarpinæ

These are made of the nitrate in strength $\frac{1}{500}$ grain.

The hydrochlorate of pilocarpine may be used as well as the nitrate.

Collyria and lotions

17. Collyrium zinci sulphatis

Zinci sulphatis	gr. j ad ij
Aquæ destillatæ	℥j

18. Collyrium zinci sulphatis cum atropinâ

Zinci sulphatis	gr. j
Atropinæ sulphatis	gr. j
Aquæ destillatæ	℥j

19. Collyrium zinci chloridi

Zinci chloridi	gr. ij
Aquæ destillatæ	℥j

20. Collyrium aluminis

Aluminis	gr. v
Aquæ destillatæ	℥j

Alum preparations must be used with care, as they have a tendency to dissolve the corneal tissue, and therefore must never be prescribed in cases of keratitis or corneal ulcer.

21. Collyrium argenti nitratis

Argenti nitratis	gr. j ad ij
Aquæ destillatæ	℥j

22. Collyrium cupri sulphatis

Cupri sulphatis	gr. ij
Aquæ destillatæ	℥j

23. Lotio plumbi

Plumbi acetatis	gr. ij
Acidi acetici diluti	♏ij
Aquæ destillatæ	℥j

24. Lotio acidi borici

Acidi borici	gr. v ad x
Aquæ destillatæ	℥j

25. Lotio boracis

Sodii biboratis	gr. x
Aquæ destillatæ	℥j

26. Lotio boracis cum glycerino

Sodii biboratis	gr. x
Glycerini	ʒss
Aquam destillatam ad . .	℥j

27. Lotio sodii bicarbonatis

Sodii bicarbonatis	gr. x ad xv
Aquæ destillatæ	℥j

28. Lotio acidi hydrocyanici

Acidi hydrocyanici diluti . . .	♏v
Aquæ destillatæ	℥j

29. Lotio salicylatis

Sodii salicylatis	gr. xl
Acidi salicylici	gr. j
Cocainæ salicylatis	gr. iij
Aquæ destillatæ	℥viij

30. Lotio acidi salicylici cum borace

Acidi salicylici	gr. iij
Sodii biboratis	gr. v
Aquæ destillatæ	℥j

31. Collyrium quininæ

Quininæ sulphatis	gr. j ad ij
Acidi sulphurici diluti	q.s.
Aquæ destillatæ	℥j

32. Collyrium opii

Opii extracti liquidi	ʒj ad ʒij
Aquam destillatam ad	℥j

33. Lotio potassii permanganatis

This is made by mixing 10 to 20 drops of Condy's solution to the oz. of water.

34. Lotio hydrargyri perchloridi

Hydrargyri perchloridi . . .	gr. $\frac{1}{16}$ ad $\frac{1}{8}$
Aquæ destillatæ	℥j

35. Lotio argenti nitratis

Argenti nitratis	gr. ij
Aquæ destillatæ	℥j

36. Lotio acidi carbolici

Carbolic acid is dissolved in distilled water, and is used of different strengths (1 in 20, 40, 100) as required.

Fomentations

37. Fomentum acidi borici

Acidi borici	ʒvj
Aquæ ferventis	Oj

38. Fomentum boroglyceridi

Boroglyceridi	ʒj
Aquam ferventem ad	Oj

Boroglyceride is prepared by heating together in a water-bath 2 parts of boric acid and 3 parts of glycerine.

39. Fomentum papaveris

Two oz. of bruised poppy capsules are boiled in a pint of water or half an hour, and then strained.

Ointments

40. Unguentum hydrargyri oxidi flavi

Hydrargyri oxidi flavi	gr. iv.
Paraffini mollis	℥j

This may be made up as 2, 8, or more grs. to the oz.; the B.P. ointment is 10 grains to the oz.

41. Unguentum hydrargyri oxidi flavi cum atropinâ

Hydrargyri oxidi flavi	gr. iv.
Atropinæ	gr. j
Paraffini mollis	℥j

42. Unguentum hydrargyri nitratis dilutum

Unguenti hydrargyri nitratis (B.P.) .	ʒj
Paraffini mollis	ʒvij

43. Unguentum iodoformi

Iodoformi præcipitati	ʒj
Unguenti paraffini	ʒvij

44. Unguentum zinci

Zinci oxidi . , ...	gr. xxx
Paraffini mollis	℥j

The B.P. preparation is about 70 grains to the oz.

45. Unguentum acidi borici

Acidi borici	gr. xv
Unguenti paraffini	℥j

The B.P. ointment is about 40 grains to the oz.

Caustics

The *actual cautery* (fig. 22) is the best way of applying cauterisation to the eye. The bulb is heated in the flame of a spirit lamp till it becomes of a dull red heat, and is then applied to the surface of the corneal ulcer by its apex or bulb. In treating corneal ulcers by this means, it is important to remember that the operator must aim at excess rather than insufficiency in the cauterisation.

Solid nitrate of silver should never be applied to the conjunctiva, but may be used to stimulate a chronic corneal ulcer, or to burn a wart on the eyelid.

46. Mitigated solid silver nitrate stick

This is made by fusing nitrate of potash with nitrate of silver in the proportions of 2, 3 or 4 to 1.

Sulphate of copper

Pointed crystals of sulphate of copper are used to touch the granulations in granular conjunctivitis.

Alum

Crystals or sticks of solid alum are employed to cauterise the conjunctiva.

47. Lapis divinus

Equal parts of sulphate of copper, nitrate of potash, and alum in powder are fused in an earthen crucible, with the addition of a fiftieth part of powdered camphor. When cold, the mixture is run into moulds, so as to form short pointed sticks.

48. Pasta caustica (Vienna paste)

Zinci chloridi	gr. 480
Farinæ	gr. 120 vel q.s.
Liquoris opii sedativi	℥j

The ingredients must be mixed smoothly in a mortar, and heated over a warm bath till of proper consistency.

49. Fluorescin solution

Fluorescini	gr. x
Sodii bicarbonatis	gr. xv
Aquæ destillatæ	℥j

This is used as a staining material. A single drop placed in the conjunctival sac will stain an ulcer of the cornea or conjunctiva bright green in the space of a minute.

50. Infusum abri

This is prepared from the jequirity seeds, which are crushed into a powder. One drachm of the powder is soaked in 12½ dr. of water at 120°; the mixture is left till cold, and then decanted and strained through muslin.

The infusion is active for several days, and its action depends on a nitrogenous ferment.

It is used by painting the solution on the palpebral conjunctivæ in cases of chronic granular conjunctivitis.

Counter-irritants

Linimentum iodi may be employed by painting it over the brow till the skin is tender or even sore; this method of treatment is especially useful in cases of photophobia in children.

Blisters.—Emplastrum cantharidis is generally used, and should be applied about 1 in. × 1 in. square in the temporal region, in front of the ear, or over the mastoid process. A mild and convenient form of blister is mustard leaf in pieces about half an inch square to the temporal or superciliary region; they may, in some cases, be applied for only a few minutes (flying blisters).

A *seton*, consisting of a piece of thick silk, is usually applied behind the ear. The silk is threaded in a large needle, and a piece

of skin over the mastoid process being pinched up between the finger and thumb, the needle and silk are passed through the fold, and the silk afterwards tied in a knot, thus forming a circle. This is left in for weeks or months, and sets up considerable irritation and discharge; the silk should be shifted a little every two or three days.

Leeches may be used from one to four at a time. The best way to apply them is by placing the leech in a narrow (leech) tube. The tube is held over the spot selected, which has previously been cleaned, until the leech fastens on. Sometimes it is necessary to place a drop of milk, or to prick the spot, to induce the leech to feed. They are usually left till they drop off of their own accord; if the bleeding afterwards is too severe, it can be stopped with a pressure pad.

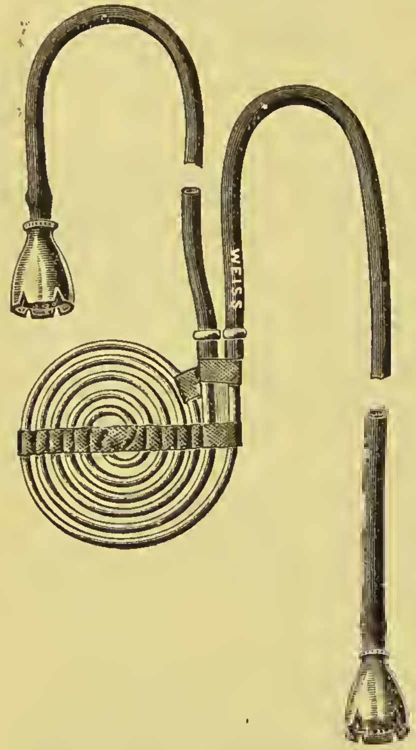


Fig. 105.—Leiter's Tubes

Hæmostatics.—For checking excessive hæmorrhage, occasionally found after excision, hot water is the best remedy, and should be applied by absorbent cotton-wool pads, wrung out with boiling water. Failing this, hazeline or tincture of perchloride of iron must be applied on strips of linen. In cases of intra-ocular hæmorrhage, cold compresses should be used, or Leiter's tubes.

Leiter's tubes (fig. 105) consist of a flat spiral lead tube made to fit over the eye, and connected with two indiarubber tubes. One of these rubber tubes is placed in a receiver of water raised above the patient's head; and the other one, hanging down, conveys the fluid which has circulated into a basin.

By this means a constantly circulating current of cold or hot water may be kept up. It is best in most cases to cover the skin of the lids with a piece of lint before applying the tubes.

GENERAL RULES FOR OPERATING

Preparation of patient.—The patient should be accustomed to his immediate surroundings for at least twenty-four hours previous to the operation; this is to ensure his being used to the bed, which, if possible, should be furnished with a hair mattress, and on no account a feather bed. The bowels should be opened by a mild aperient taken the night previous to the operation, and the patient should have a complete bath.

An hour before the operation, the face should be well washed with soap and water, and afterwards sponged with corrosive sublimate solution (1 in 4,000) or weak carbolic lotion.

The *operating-room* must be thoroughly aired, the floors well scrubbed, and the walls cleaned down the night before, or morning of the operation. For this reason operating theatres should have tiled walls and concrete floors.

As it is necessary to obtain as good a light as possible on the eye, the operating table should preferably be placed opposite a window facing north. It is important not to have a top light.

Dressings.—Bandages, cotton-wool or gauze, ought to be subjected to superheated steam at 110° to 120° C. in a steriliser for at least thirty minutes. The sponges should be of sterilised absorbent cotton-wool, and may be kept ready for use in a saturated solution of boracic acid.

It is usual to place next to the eye a piece of soft linen, cut about the shape and size of the orbital aperture. The surface next to the eye should be smeared with freshly made boracic acid ointment, so as to allow the tears to pass away and to prevent the lids sticking together.

Graduated pads of boracic or absorbent cotton-wool are then laid over the eyes in order to fill up the hollow of the orbit, and a bandage applied. In excision cases, cyanide gauze may be used instead of cotton-wool.

Eye bandages.—These should be light and porous, and are best made of mull muslin, about 6 yards in length, and torn into strips $1\frac{1}{2}$ to 2 inches wide.

To bandage one eye.—A simple method is by a single turn of a bandage passed over the eye below the ear of the same side, and tied on the parietal eminence of the opposite side. The difficulty is to avoid covering the good eye and, at the same time, to keep the bandage firm. The bandage should always be started from the opposite side to the eye intended to be covered.

A more secure method to bandage one eye. Left eye (figs. 106 and 107).—The starting point (dotted line in fig. 106) is just below the right parietal eminence, and the bandage must be unrolled round the forehead above the brow, and then below the occipital protuberance to the starting point. The bandage should here be reversed and brought obliquely downwards over the left eye, under the left ear, round the nape of the neck to the starting point, where a pin unites the folds. About 18 inches of the bandage are then torn off, split into

FIG. 106

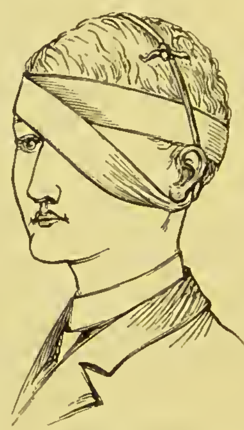


FIG. 107

two and the tails taken across the vertex, one being passed behind the left ear, under the lower fold, brought up over it, and tied near the vertex (fig. 107) to the other tail.

To bandage both eyes.—The bandage should start just above the right ear, and be brought forward round the head above the supra-orbital eminences, and then below the occiput to its starting point. It is then directed obliquely downwards over the left eye, under the left ear, round the nape of the neck, under the right ear, and obliquely upwards over the right eye, left brow, following the other turns of the bandage as far as the

starting point. A pin is now passed through all the folds at this point, and about 18 inches of the bandage torn off and split in two; the tails of the bandage are passed across the vertex, and one tail is taken behind the left ear, passed behind and below the turn of the bandage under the left ear, and tied on the vertex of the head to the other tail.

The bandage (fig. 108), which I generally use, is very convenient unless much pressure is to be applied to the eye. It should be made of long cloth or linen, about 11 inches long and $2\frac{1}{4}$ wide, except at the peak, where it is 3 inches wide; at the upper and lower angles, at either end, are two tapes to go above and below the ears, and long enough to pass round the back of the head and tie in front over the peak.

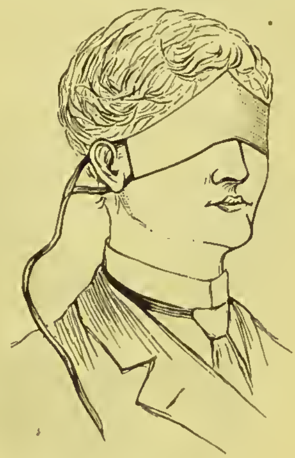


Fig. 108

To apply pressure, the most effectual way is by a broad strip ($2\frac{1}{2}$ to 3 inches wide) of Leslie's plaster, which must be put on obliquely, from below the opposite frontal eminence, passing across the cheek to the angle of the jaw on the side of the eye to be strapped.

Isinglass plaster dressing is a light convenient form, which will remain on for a week without renewal, does not slip, and exerts moderate pressure. An oblong piece of isinglass plaster (6 inches by 3 inches) is held in water of about 100° for fifteen seconds. It is then placed obliquely across the dressings covering the eye, from the forehead over the bridge of the nose and eye to below the malar eminence. It must be pressed on carefully, and gently rubbed with two pieces of wet wool; a good plan is to strengthen the upper border by a strip of the same plaster.

The *instruments* must be absolutely clean and rendered aseptic. This is best done by boiling them for twenty minutes before the operation, or placing them in a hot-air chamber for the same length of time. Ivory-handled instruments will not stand boiling, and the handles should if possible be of aluminium or German silver. The cutting properties of knives are

liable to be affected by boiling water, and they should only be dipped into it, and then into absolute alcohol.

Every knife should be tried as to its point and cutting edge on the drum (fig. 109), which consists of a small cylinder covered with kid tightly stretched over it. If the point of the knife does not perforate the kid noiselessly and easily, almost by its own weight, it is not fit for use. The edge should be tried also on the drum. Scissors must be tested on the kid to see that they cut true to the points.

Anæsthetics. General.—Since the introduction of cocaine, general anæsthetics are much less frequently given for eye operations, except in cases of small children, or for enucleation, iridectomy in glaucoma, and blepharal operations. If a general anæsthetic is necessary, chloroform should be used, as the vessels of the eye do not become so congested as with ether. The grave objection to a general anæsthetic, in operations where the eye is opened, is the vomiting which frequently follows its administration.

Fig. 109.—Drum

Local.—Cocaine is usually employed, and generally as a 4 per cent. solution of the hydrochloride; it must be made with distilled and sterilised water immediately before use.

Method of using.—A drop should be placed in the eye four times before the operation—namely (1) ten minutes before; (2) five minutes before; (3) immediately before the patient is placed on the table; (4) after the eye has been irrigated. If the iris is to be operated on, another drop should be put in after the corneal or scleral section.

The advantages of cocaine are that it is easily applied and, except in cases of congestion of the eyeball or increased tension, produces sufficient anæsthesia of the conjunctiva, cornea, and even iris. The disadvantages are that it makes the section of the cornea and the delivery of the lens more difficult, as

it produces a flaccid cornea and a decrease of intra-ocular tension. Cocaine also tends to dry the corneal surface, leading sometimes to loss of epithelium.

Hypodermic injections of cocaine (4 to 10 per cent.) are used to obtain anæsthesia in cases of tenotomy or small lid tumours. Corrosive sublimate solutions should never be employed to wash out the eye if cocaine drops are used, as a white precipitate is thrown down, which produces irritation of the corneal wound. The mydriasis induced by cocaine may be counteracted by eserine.

Eucaine hydrochloride in 5 p.c. solution has been used for local anæsthesia by many oculists, but I prefer cocaine. When instilled into the conjunctival sac, it produces a great deal of smarting, lachrymation and conjunctival congestion. Its only advantage seems to be that the pupil is unaffected.

Position of patient.—The patient should be lying on a table of a height convenient to the operator, and his head slightly raised on a pillow.

Position of operator.—The operator should stand behind the patient's head, except in tenotomy of a lateral rectus. If unable to operate with his left hand, he must stand in front and to the left of the patient when performing upward extraction of the left lens.

An *assistant*, if required, stands on the right side of the patient, and hands the instruments, sponges, &c.

Irrigation of the eye.—The conjunctival sac should be thoroughly washed out with distilled water or boracic acid solution (7 gr. to the oz.) after the speculum is inserted. The most convenient way is by means of a retort-shaped bottle called an undine (fig. 110), which ensures a continuous stream; a syringe will also answer the purpose, and another method is to soak absorbent cotton-wool in the solution and let the fluid drop from it in the eye.

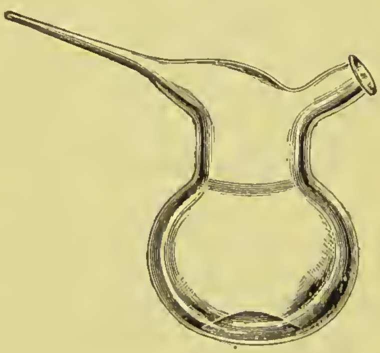


FIG. 110.—UNDINE

Care of patient after operation.—If the interior of the eye

has been opened, great care must be taken during removal of the patient from the operating table to the bed. He should not be allowed to make any muscular exertion, and on being placed in bed must remain on his back. This position is the best one, at all events for the first twenty-four hours, as, if the patient is allowed to turn over towards the non-operated-on side, he will probably in his sleep roll over to the opposite side.

In cases of cataract extraction, especially if performed without an iridectomy, the patient should be watched by day and night for forty-eight hours, as it is generally during that time that a prolapse of the iris may occur.

I prefer the hands to be tied down with a bandage for the first two nights.

For the first forty-eight hours the patient should be fed on fluids, or at most very finely minced soft meat, to avoid the jar caused by the movements of mastication.

LENSES, SPECTACLES, &c.

Lenses are now usually measured by the metrical system, and the standard taken is the lens of 1 metre (40 inches) focal length; this lens is called a dioptre, and is expressed as 1 D. From this standard all other lenses are calculated; thus a glass of 2 dioptres, being twice as strong as the standard, has a focal length of ·5 metre (20 inches); one of 4 dioptres has a focal length of ·25 metre, and so on. Originally, in England, all glasses were marked according to their focal length in inches; thus a lens of 40 inches was called $\frac{1}{40}$, &c.

Spherical lenses are divided into convex, designated by the symbol +, and concave by −. As a rule they are either bi-convex or bi-concave, the anterior and posterior surfaces being curved similarly; thus a + 6 D. lens has a curvature of + 3 D. in front and + 3 D. behind, and a − 15 D. lens would have a curvature of − 7·5 D. in front and − 7·5 D. behind. Lenses are also made in such a way that one surface is convex and the other concave. These are called periscopic, and for convex glasses up to 3 D. give a wider and better field. These concavo-convex (meniscoid) lenses should always be worn so that the concave surface is posterior and next to the eye, and the proportion should be as a rule one to five. Thus a lens of + 1 D. would have its concave posterior surface − 2 D. and its anterior convex surface + 3 D.

Concave glasses are generally made double concave, but deep lenses, as from 8 D. upwards, are best made plano-concave.

Cylindrical lenses are made from a cylinder, and one side is plane glass. In ordinary cylindrical glasses it is advisable, if possible, that the cylinder used should be a concave. Mixed spherical and cylindrical glasses are made, with the spherical one side and the cylindrical the other.

Prisms are made either according to the geometrical or the visual angle. The geometrical angle is the one represented by

the prism itself; that is, the lens is worked at an exact angle from base to apex according to the degrees required. The visual angle is the angle at which an object is deviated at any given distance. An angle of 4° deviation would displace the light of a candle 4°, and, roughly speaking, a prism with a visual angle of 1° deviation is equal to a 2° geometrical.

Trial case.—This should contain convex, concave, cylindrical, and prismatic lenses, trial spectacle frame, obturator discs (slit and pinhole), red and green glass.

A complete set of trial lenses (two of each) includes the following:

Spherical convex: ·25, ·5, ·75, 1, 1·25, 1·5, 1·75, 2, 2·25, 2·5, 2·75, 3, 3·5, 4, 4·5, 5, 5·5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20.

Spherical concave, of corresponding strengths.

Cylindrical convex: ·25, ·5, ·75, 1, 1·25, 1·5, 1·75, 2, 2·25, 2·5, 2·75, 3, 3·5, 4, 4·5, 5, 5·5, 6.

Cylindrical concave, of corresponding strengths.

Prisms: 1°, 2°, 3°, 4°, 5°, 6°, 7°, 8°, 9°, 10°.

Trial frames should be arranged so that two lenses, one behind the other, can be placed in each eyepiece, and should have movable shutters and adjusting screws for increasing the distance between the eyepieces, and for altering the height of the bridge; the eyepieces should be marked with the number of degrees from 0° to 180°, starting from the nasal side.

Obturators; one should have an oblong slit from 1 mm. to 2 mm. wide, and is used for correcting and estimating astigmatism (p. 398); another should have a pin-point aperture. This latter is very useful in determining whether a visual defect is due to refraction or to some pathological change. If a refraction error is present, the patient will be able to see very much better and in many cases $\frac{6}{6}$ with the pin-point obturator.

For estimating ordinary refraction without astigmatism, the following sixteen lenses can by combination be arranged to correct most errors. Convex ·25, ·5, 1, 2, 3, 6, 7, 14, and concave from ·5, 1, 2, 3, 6, 7, 14, 20.

Spectacles.—After having found the refraction of the patient and the glasses to be ordered, it is necessary to measure him for spectacles. They should be accurately centred, sit well on the nose, be at a distance from the eyes sufficient to allow the

lashes play without touching the glasses. They must be strong and light, and made of gold or steel; the latter tend to rust, and therefore should never be ordered for use in hot or moist climates. The sides of the frames may be straight, or curled at the ends to fit round the ears.

The bridge must be very carefully adapted to the nose so as not to indent it; in children the bridge should be broad. The eyepieces are generally oval or round oval (flattened above); in children with any tendency to squint, they are best made circular.

To measure for frames.—The distance is first taken between the centre of the pupils, and the height of the bridge of the nose measured; the relative position of the nasal bridge and eyelashes is then noted.

Convex glasses. For reading, the rule is to make the centres one-eighth narrower (internally) than the pupillary centres; for distance, the centres should correspond with the pupillary.

Concave glasses. For reading, the centres should correspond with the pupillary centres. For distance, the glasses should be 'full wide,' and frequently it is an advantage for the centres to be one-eighth wider than the pupillary centres, and the lenses should be worn as close to the eye as possible, even touching the lashes.

If the same pair of spectacles is to be worn for distant and near vision, the pupillary centres should as a rule correspond with the centres of the lenses. In concave glasses, the spectacles ought to sit well up on the face, and the centres should be 'full wide.' Convex glasses should be worn rather low, and the centres 'full narrow.'

Spectacle lenses are made of crown glass or rock crystal (pebbles); the latter have the advantage of being harder and less liable to be scratched, but are apt to have many flaws and striæ, producing unequal refraction, added to which they are more costly. They must be cut exactly at right angles to the optic axis, or unequal refraction is produced. For all practical purposes, the best crown glass is preferable for spectacle lenses.

The method employed in their manufacture is to cut the glass with a diamond into pieces 1½ inch square, and then to chip the edges with iron shanks till they are circular. The surface is made of the required curvature by instruments called roughing tools, which are in shape just the reverse of the glass;

thus, for a convex glass, a concave roughing tool is used. Some coarse emery powder is placed on the tool, and the glass rubbed down by it till the requisite shape is obtained, when the surface is polished by fine emery powder. After about fifteen pieces are prepared, these are cemented on a runner, and are then rubbed in the finishing tool with the fine emery powder, and afterwards polished with a piece of cloth previously cemented to the tool.

Though spectacles are preferable, many people use pince-nez. The ordinary pince-nez which fold up may be ordered in cases of simple hypermetropia, myopia, or presbyopia; but in cases of astigmatism, the straight kind, generally known as novel nippers, should be ordered. The use of a single eyeglass is, as a rule, to be condemned, as it tends to induce monocular vision, but it may be worn in cases where the sight of one eye is markedly inferior to the other.

Glasses should be worn as close to the eyes as the lashes will allow, except in cases of presbyopia, when the patient will probably find them more convenient if worn lower down the nose.

Bifocal (Franklin's) glasses are those in which the lens is so made that the upper part is of a different focus to the lower; the upper portion is adapted for seeing at a distance, and the lower for near objects. They may either consist of two glasses joined across the middle, or of one piece of glass ground of different thickness, or a fine layer of glass cemented on one portion. They are especially useful for myopes or presbyopes with an error of static refraction.

Prisms are rarely used over 4°, partly owing to their weight, for insufficiency of convergence or paralysis of a muscle; the higher prisms are employed sometimes in detecting malingering.

Decentring glasses.—Convex and concave lenses may be made to act as slight prisms by so adjusting them that the patient looks through the edge instead of through the centre of the glass; thus, spectacles of 3 D. decentred in produce the action of a 1° prism with base inwards.

Stenopaic spectacles.—The eyepieces are made of discs of vulcanite with a small central oblong aperture, in order to confine the vision of the patient to a certain direction.

They are used in cases of corneal nebula or leukoma, conical cornea, irregular astigmatism, and lenticular striæ.

To estimate the strength of a glass.—The observer holds the glass before his eye, and looks at a distant object, such as a window or letters. He now moves the glass from side to side and from above downwards, and if the object looked at does not appear to move, the glass is plane; if it moves, the glass has a spherical or cylindrical value. In the latter case, lenses of known strength should be placed in front of the glass until objects seen through the combined lenses do not appear to move. For spherical glasses, a quick way is to rotate the chain of lenses in a refraction ophthalmoscope before the glass to be estimated.

The quickest method is by means of the lens measure, an instrument made by the General Optical Company, Chicago. This is one of the most useful adjuncts to refraction, as in a few seconds the strength of the glass can be accurately found, and also that of the surfaces.

Tinted glasses for the protection of the eyes from the sun or glare are usually either of a neutral or blue tint, and may be made either plane or correcting the patient's refraction.

The depth of tint varies from a very slight grey or blue to an almost black (electric) or very dark blue, and numbers have been given to the different shades of colour. The grey (smoked) colour is used in cases in which the quantity of light has to be reduced, and the blue when the quality is to be subdued.

A colour called peacock green is useful in cases of retinal, choroidal, or optic nerve disease.

Goggles are made with the framework of fine wire gauze or black crape, and should fit close to the margins of the orbit so as to protect the eye completely from wind, dust, and light.

Dome (cupped) glasses are hollowed out lenses, also forming a protection.

Shot-proof spectacles are made of extra stout pebble of Brazilian quartz, and may be dome shaped or with side pieces. The advantage of these spectacles is that if struck by shot the lens is simply split, and does not splinter backwards like glass.

Spectacles with the eyepieces of mica or talc are used by workmen employed in occupations as stone-breaking, &c.

Optometers are instruments for estimating the refraction without resorting to the trial case, except for verification, and have been arranged on several different principles. They are useful in the hands of a careful and competent observer, and

are then a saving of time, especially if a number of candidates have to be examined. The best form is that invented by Mr. Couper.

The *stereoscope* is useful in aiding the restoration of binocular vision after squint operations. The best form is a simple box stereoscope $\frac{1}{6}$ m. in length; the object slide should consist of two vertical lines (a red and black) which can be moved nearer and farther apart with a scale marked on it in centimetres.

Method of using.—If the patient is emmetropic, + 6 D. lenses are placed in the eyepieces of the stereoscope, and the objects moved as far apart as possible with the maintenance of binocular vision. As soon as binocular vision is obtained in this way with parallel optic axes, the number of centimetres the objects are apart is read off on the scale. The objects are then moved about 1 cm. closer to one another, and + 5 D. glasses substituted for the + 6 D.; if the patient can now attain binocular vision for this distance, similar procedure is adopted with + 4 D., + 3 D., + 2 D., + 1 D., the objects being in each case approached closer.

The patient ought now to be able to obtain binocular vision without glasses, and will then be using 6 m.a. of convergence at $\frac{1}{6}$ m. distance. If the patient is hypermetropic or myopic, he must wear spectacles correcting his error when using the stereoscope.

Shades ought as a rule to cover and protect both eyes above and also at the sides. They are usually constructed of thin cardboard covered with silk, of stout dark paper, or of black plaited straw.

The *colour vision plate* is taken from Prof. Holmgren's 'De la Cécité des Couleurs, &c.,' 1877. It is intended to represent the three colours (1, 11A, 11B) usually employed in tests, and beneath each horizontal strip are the colours most often confused with it.

The colours mistaken for, or matched with, the green (No. 1) are pale yellows, buffs, pinks (1 to 5); with the rose pink (No. 11A), purples, blues of different amounts of saturation, and greys (6 to 9); with the scarlet (No. 11B) are greens, browns (10 to 13).


I.
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IIa.
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IIb.
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REGULATIONS FOR VISION TESTING, &c. OF CANDIDATES FOR THE GOVERNMENT SERVICES [1]

Home Civil Service.—The commissioners refer each case to a competent medical adviser, leaving him to apply whatever tests he thinks necessary for the particular appointment.

Royal Navy.—A candidate must be emmetropic and able to read $\frac{6}{6}$ with each eye, and his range of accommodation must be perfect.

Squint or any defective action of the extrinsic ocular muscles, or any imperfection in colour sense, disqualifies.

The Army, including the Medical Department.—A candidate must with each eye separately, without glasses, read at least $\frac{6}{36}$. If he can read $\frac{6}{36}$ with either eye, he may be passed as fit if with correcting glasses he can read $\frac{6}{6}$ with one eye, and at least $\frac{6}{12}$ with the other eye, provided that at the same time he can read ·8 type with one or both eyes, without glasses, at any distance he likes.

Squint, colour-blindness, or any disease of the eye liable to recur, will cause him to be rejected.

In examination for recruits, circular black spots, corresponding at 10 feet with a bull's-eye 3 feet in diameter at 600 yards, are held before the examinee, who is expected to tell the number and relative position of the dots exposed.

[1] For full particulars see *Regulations as to Physical Defects which Disqualify Candidates for Admission into the Civil or Military Government Services*, by N. C. Macnamara. J. & A. Churchill, 1894.

Indian Civil Service (Covenanted and Uncovenanted).—A candidate must be able, with or without glasses, to read at least $\frac{6}{9}$ in one eye, and $\frac{6}{6}$ in the other, and there must be no morbid fundus changes. A myope, with a posterior staphyloma, may pass, provided the myopia do not exceed 2·5 D.

A nebula of the cornea will disqualify if the sight of either eye be less than $\frac{6}{12}$; and in such a case the vision of the better eye must be $\frac{6}{6}$, with or without glasses.

Paralysis of an extrinsic ocular muscle disqualifies.

A case of squint cured by operation, but without binocular vision, may be passed, provided that the movement of each eye be good, and the acuity of vision reaches the regulation standard.

Indian Medical Service (Covenanted and Uncovenanted).—A candidate must have, with or without glasses, vision of $\frac{6}{6}$ in one eye, and at least $\frac{6}{12}$ in the other.

The total hypermetropia and myopia must not exceed 5 D. Astigmatism does not disqualify, provided the combined spherical and cylindrical glasses do not exceed 5 D.

Colour-blindness, paralysis of one or more of the extrinsic ocular muscles, or disease of the fundus disqualify, but a faint corneal nebula reducing vision in that eye to $\frac{6}{12}$ does not disqualify if the other eye be healthy, emmetropic, and have normal vision.

Department of (Indian) Public Works, Forests, Survey, Telegraph, Railway, Factories, Police.—A candidate must have, with or without glasses, a vision of not less than $\frac{6}{9}$ in one eye and $\frac{6}{6}$ in the other eye, except in a case with nebula of one cornea, when the vision in that eye must not be less than $\frac{6}{12}$; provided also the other eye is emmetropic and has normal vision.

A candidate may be myopic to 2·5 D., provided that, with glasses not exceeding this amount, the vision of one eye is $\frac{6}{9}$ and the other $\frac{6}{6}$. Myopic astigmatism does not disqualify if the combined spherical and cylindrical glasses do not exceed 2·5 D.

The absolute hypermetropia must not exceed 4 D., and the vision under atropine must be at least $\frac{6}{9}$ in one eye and $\frac{6}{6}$ in the other, with + 4 D. or a lower power.

In hypermetropic astigmatism the combined lens must not exceed 4 D.

Colour-blindness or paralysis of an extrinsic ocular muscle disqualifies.

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